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# *Clearing the Air*

A NUMBER of steps have been taken in recent years to reconcile growing public insistence on the abatement of air pollution with technical and economic problems experienced by industry in this field. The First International Congress on Air Pollution, held in New York recently to mark the 75th anniversary of the American Society of Mechanical Engineers, has not pointed to the solution, but it will provide a valuable starting point for further attacks on the problem in the various individual countries that were represented. These included not only the United States and Canada, but also Britain and countries on the European continent.

The removal of sulphur dioxide from flue gases came in for a good deal of attention and some interesting methods were described. One was the Fulham-Simon-Carves ammoniacal liquor process; the results obtained with this method were discussed by Mr. H. E. Newall of the Fuel Research Station, D.S.I.R. Another was the Battersea process, described by Mr. R. L. Rees, chief chemist of the British Electricity Authority, for the removal of sulphur dioxide from power-plant stack gases. Mr. Rees also spoke on a topic which was much in evidence at the Congress—the question of how tall chimney stacks should be and how much reliance should be placed on them. From the American side, a good deal was heard about sulphur recovery at oil refineries, while Prof. A. J. Ter Linden, of Delft, described advances in combating air pollution in the Netherlands.

These and numerous other contributions to the conference will be summarised in an authoritative report which we shall be presenting in CHEMICAL & PROCESS ENGINEERING shortly.

Meanwhile, we turn to a Symposium on the Prevention of Atmospheric Pollution in the Chemical Industry which was held by the Society of Chemical Industry in London last month. The opening paper was read by Mr. W. A. Damon, C.B.E., Chief Alkali Inspector of the Ministry of Housing and Local Government, whose remarks—as one who has spent over 40 years in chemical industry, the last 35 as an alkali inspector—are well worth noting. He pointed out that it is usually the treatment of large volumes of gas, containing a relatively low concentration of a noxious constituent, that poses the greatest problems. Any process from which a noxious gas is evolved should be critically examined, for it may be that by some change in technique or raw material the amount of noxious constituent may be reduced or perhaps even eliminated. Where such noxious constituent forms an essential part of the reagents employed, the object should be to retain it within the system by the efficient design, maintenance and operation of the plant.

After speaking of the air pollution control problems encountered in the steel and carbonisation industries, Mr. Damon referred to the production of high-grade metallurgical lime which must be virtually free from sulphur. This presents the difficulty that coal appears to be the only wholly satisfactory heating medium. A great deal of research has been carried out and great efforts have been made, notably by I.C.I. (Lime) Ltd., to develop an alternative technique, but up to now the problem remains to a great extent an unsolved one.

A great deal of uneasiness has been caused in recent years because of the incidence of fluorosis in cattle grazing in the vicinity of industrial processes which discharge fluorine compounds. The most serious case was connected with the electrolysis of bauxite for the production of aluminium in Scotland. Substantial improvement is understood to have resulted from segregation of hydrogen fluoride into a small volume of gas which is then scrubbed with caustic soda. The electrolytic cells employ Soderberg electrodes which are baked *in situ*. The tarry fumes arising therefrom contain no fluorine, but are unpleasant. Certain clays and ironstones also contain fluoride, which is partially decomposed on heating, resulting in a very small concentration in the waste fire gases. As yet, no satisfactory method of eliminating the fluorine has been developed.

Other problems discussed by Mr. Damon included those which have arisen in connection with the use of fluorspar as a flux in open-hearth steel furnaces, and he concluded his paper with a warning to manufacturers that there will be more and more insistent demands for the abatement of pollution and that, although the recovery of by-products may sometimes offset the cost of waste-gas treatment, the measures that must be taken will more often constitute a charge on the process which will have to be faced with or without cheerfulness.

### *High hopes for cheap titanium production in Canada*

A TEAM of research scientists in Shawinigan Falls, Quebec, has now moved a key step closer to creating the firm foundation on which a major new Canadian industry may be built. Near one of the greatest concentrations of cheap hydroelectric power in North America, they are using Shawinigan Water & Power Co.'s cost-cutting, electrolytic, continuous process to make small amounts of high-grade titanium metal in a new pilot plant. The company has made no further comment on the situation since their announcement some time ago, but sources close to the situation say the process has been working very well and that officials are more than happy about results.

When the new process was announced last April, following successful laboratory experiments, it was indicated that it might mean substantially lower prices for titanium. This hope is now brighter than ever, it is reported.

The pilot plant, in which the Federal Government is vitally interested because of the critical need for titanium in defence, has been operating only since late last autumn. However, it is understood to be working so well that officials are now looking ahead to commercial production. Bringing a process out of the pilot-plant stage is always a big jump, but successful operation at this lower level is regarded as a major step forward. Shawinigan are likely to spend at least another few months working with the pilot plant, then the stage will be set for semi-commercial and finally commercial production.

The development might lead to the foundation of a large new Canadian industry, based on Canada's own know-how, raw materials and power. Cost has been the main problem to beat in placing titanium into its recognised place as a structural metal. But it now looks as if Shawinigan's process could be the first to bring the price down with higher production.

A third point of significance is that Shawinigan uses slag from Quebec Iron & Titanium Corporation's Sorel, Quebec, smelter.

### *A new oil refinery for Australia*

THE first refinery in Australia to produce gasoline by the catalytic cracking process was officially opened recently at Altona, 12 miles from Melbourne. Built for the Australian refining subsidiary of Standard-Vacuum Oil Co., this 25,000-bbl./day plant has been in operation for four months. It will provide more than 16% of the Commonwealth's demand for petroleum products and 20% of its gasoline requirements. The refinery's output is expected to save Australia more than $2 million a year in foreign exchange.

Altona is the third of three major post-war additions to Standard-Vacuum's refining capacity in the Eastern Hemisphere, doubling the company's 1952 manufacturing output, at a total cost of more than $85 million. New refineries at Durban, South Africa, and Bombay, India, began operation last year. Stanvac has had a 2,000-bbl./day lube oil and asphalt refinery on the Altona site since 1949, but the 12-fold expansion of facilities makes the refinery virtually a new plant.

Constructed for Standard-Vacuum Refining Co. Pty. Ltd. by the Braun Transworld Corporation U.S.A., at a cost of $30 million, the refinery is manufacturing—besides catalytically processed high-octane gasoline—kerosene, aviation turbo fuel, diesel oils, lubricants, fuel oils and asphalt. When an alkylation unit is added next year, 1,600 bbl./day of high-grade aviation gasolines will be produced, also the first to be turned out in Australia.

Dominating the processing area is the 268-ft. *Thermofor* catalytic cracking unit, the heart of the refinery, which charges reduced crude and produces high-octane gasoline and other products. A catalytic reformer (*Sovaformer*), not yet completed, will upgrade heavy naphthas and improve their octane rating.

The new refinery's total output will fill more than 16% of Australia's annual petroleum requirements of 45 million barrels. The nation now ranks sixth in the world in *per capita* consumption of oil products—210 gal.—and the demand is expected to increase steadily. Crude oil for the Altona refinery comes from western New Guinea and Middle East fields, and is brought to Australia in tankers which berth at a newly installed terminal at Williamstown, five miles away.

Only about one out of five of the 500-man operating force is required to control the processing units in the modern, electronically equipped plant, the rest being engaged in maintenance and administration. Virtually all are Australians, trained overseas or on the job by American refining technicians.

**Comical Engineering Terms**

"AGITATION"

### *Warning labels for dangerous substances*

THE interesting suggestion that the chief role of the world's chemical industries should be to expand production of inexpensive synthetic fibres and to develop those branches of the industry which help to increase the output of food, was among points which came up for discussion at the Fourth Session of the Chemical Industries Committee of the International Labour Organisation, held in Geneva recently. This suggestion appeared in a part of the general report, which was dealt with by the committee along with a number of topics concerning productivity, safety and hygiene in the world's chemical plants.

Concerning productivity, the committee drew attention to the fact that in many chemical processes the worker's output is more or less rigidly determined by the nature of the equipment, materials and the length of time required for chemical reactions. These factors being present, there may be little or nothing the individual worker can do to increase his output in quantity. On the other hand, however, he may be able to effect the quality of his output as well as the unit cost of the various factors which go into the production process.

The most practical outcome of the proceedings, perhaps, was the committee's decision on the proposed danger symbols to be used throughout the world to identify the chief types of dangerous substances. This matter, which has been under discussion at various times since 1952, was carried a stage further by the definite adoption of five symbols to give warning, without the aid of words, of dangers associated with the handling of dangerous substances: explosion, fire, poisoning, corrosion and radioactivity. Though the decisions on this point were not unanimous (73 in favour, 16 against and 26 abstentions) the committee nevertheless requested the I.L.O. governing body to draw the attention of governments and international organisations to the need for recognising and adopting these symbols without delay in world trade in chemicals. The next stage by the I.L.O. will be the preparation, in consultation with expert opinion, of a basic list of dangerous substances to which the five symbols will apply.

### *Medicine machinery*

THE growing world need for medicines demands from the manufacturer a combination of engineering skill and advanced techniques of management. However, the increasing range and variety of pharmaceutical preparations tend to inhibit the use of modern production methods. This, according to the British Productivity Council's recently published booklet, 'The Machines Behind Medicines' (H.M.S.O., 2s. 3d.), is the chief problem facing the pharmaceutical manufacturer today.

But the British industry, despite its problems, cannot be said to lag behind its counterparts in other countries. For example, the American industry was found by the Pharmaceutical Productivity Team, which visited the United States in 1950, to have a higher overall productivity than exists in Britain. The team felt that, in most fields of manufacture, the British industry was at a disadvantage as regards the machinery it had available. The fact that American manufacturers had at their disposal the Fitzpatrick comminuter, for example, was mentioned frequently in their report as a main factor in the higher productivity of their tableting sections and in grinding processes. An aftermath of the team's visit, however, was increased co-operation between the Association of British Pharmaceutical Industry and the British Chemical Plant Manufacturers' Association. As a result of this, the latter organisation prepared a report listing British-made equipment either not known or not fully appreciated by pharmaceutical concerns and at the same time was able to draw the attention of plant manufacturers to the special needs of the pharmaceutical industry.

Since the publication of the team's report much new and improved processing machinery has been developed in the U.K. and it is probable that British pharmaceutical firms now have available equivalents (at least) of almost all the items of American equipment mentioned by the team.

Typical of the advance is a mill recently put on the market by a British firm which, in the opinion of many people in the industry, is at least the equal of the Fitzpatrick comminuter. The Fitzpatrick machine, incidentally, is itself now in much wider use in U.K. factories. At least two types of mill for grinding to micron sizes (a type of equipment stated by the team to be little known in this country at the time of its report) are now available from British firms. Of

special interest, also, is the development by a British company of equipment for emulsifying ointments and similar preparations by ultrasonic waves; this method, it is claimed, is quicker and requires much less power than other processes.

Among American machines now produced under licence in the U.K. is the *Votator* equipment for cooling creams mentioned by the productivity team. Other machines operating on similar principles are also available. These and other examples cited in the B.P.C. booklet are sufficient to indicate that the industry is today well served by specialist makers of pharmaceutical processing machinery.

### Chemicals from the forests

RECENT investigations in Canada at the Ontario Research Foundation have shown that huge quantities of essential oil could be obtained simply by steam distilling the coniferous foliage annually discarded by the forestry industry. The needles of spruce and balsam contain about 1% of these pleasantly odorous oils. The annual spruce cut in Ontario alone, if the wasted foliage was all processed, could produce 5 million lb. of them. But this massive potentiality creates its own problem. There is a market for this type of oil, principally for perfuming purposes—but 5 million lb. a year would considerably exceed the total demand of this market. If the large-scale application of this by-product process is to be successful, new uses for the oils must be found. It is not wholly dissimilar a problem to that of turning lignin, an even larger forestry waste, into synthetic vanilla—the process is sound, but a mere fraction of the waste can produce enough to satisfy the world market.

Chemists should be able to find a solution. These coniferous wood oils are not merely aromatic; they consist of mixtures of chemical substances, many of them belonging to the terpene family. In these days of industrial organic chemistry, terpenes should surely be useful as starting materials for synthetic processes. That they have not been given much consideration as such in the past is due to the fact that an abundant and cheap supply has not been thought possible. Industrially the chemical possibilities of terpenes have been neglected. Here, then, is a chance for some new and perhaps well-rewarding venture. If chemists can suggest ways of converting terpenes into world-needed chemicals, Canada's forestry wastes could produce the terpenes.

### Ion exchange in new sugar refining process

HIGHER yields of sugar at lower prices are claimed for a new refining process, employing ion-exchange resins to purify the cane juice, which has been devised by chemists of the U.S. Department of Agriculture. The process, which is still in the experimental stage, is said to produce a sugar ready for direct consumption which is particularly suitable for confectionery.

The Department explains the new process as follows. Clarified cane juice is passed through beds of ion-exchange resins (some of which are similar to those employed to remove hardness in water). This operation removes minerals and organic materials from the juice, resulting in increased yields of sugar. It also takes out colouring matter to give a light-coloured product approximating the colour of fully refined sugar. Refined sugar sold in stores has been crystallised at least twice.

This new reverse-cycle ion-exchange system permits the purification of cane juice without the loss of sugar by inversion (hydrolysis), which occurs when conventional ion-exchange systems are used. The conventional process removes bases first, leading to inversion of sugar in the resulting highly acid juice. The reverse-cycle process eliminates this chemical reaction, and the resulting loss of sugar, by removing the acids first.

Yields of cane sugar obtained in the laboratory by the new process were higher than those of conventional processes, it is claimed. Costs are expected to be about ½% per lb. less than refined sugar.

### Cellulose caprate from wood pulp

PLANT for obtaining cellulose caprate from degraded wood pulp has been designed and built by I.C.I. research department, Nobel Division, at Stevenston, Ayrshire. The cellulose caprate will be sold by the Ministry of Supply as an optical cement. Its properties make it particularly suitable for optical lenses used in aircraft.

The apparatus was constructed from glass plant made by Q.V.F. Ltd. Glass was used because of the ease with which the apparatus can be cleaned. Other advantages of the borosilicate glass used in this type of plant are its comparative immunity to thermal shock and high resistance to corrosion.

An outline of the process used in obtaining the caprate is as follows:

Degraded wood pulp is activated by treating with monochloracetic acid in a specially designed chemical stoneware mixer. The activated cellulose which still contains the monochloracetic acid is then esterified at constant temperature in a pot containing capric anhydride, capric acid and perchloric acid.

After 24 to 30 hr., a homogeneous solution is obtained, which is filtered. Cellulose caprate is then precipitated from the filtered solution with methanol and purified by washing with methanol. The purified cellulose caprate is collected in a glass filter column and excess methanol sucked off by vacuum. Finally, the product is dried and the powder extruded into sticks.

Capric anhydride is prepared by dehydrating capric acid with acetic anhydride and removing the excess acetic anhydride by azeotropic distillation. Capric acid and methanol are recovered from the methanol solution resulting from the precipitation and washing of the ester.

Unusual features of the plant are a gas-purged electric heating mantle for use in flame-proof areas and a specially designed mixing vessel constructed entirely of chemical stoneware.

# CENTRIFUGING

## 2. Applications in the chemical, brewing and fermentation, petroleum and other industries; auxiliary apparatus

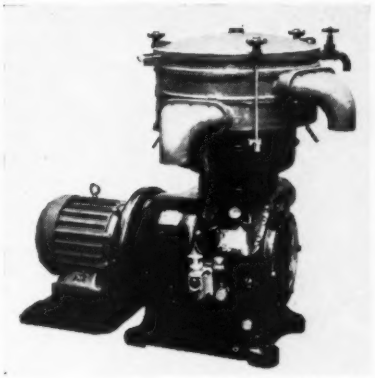
By E. Broadwell

### Chemical industries

AN article on pilot-plant studies for the manufacture of fine chemicals[146] gives details of tube centrifuging tests for the assessment of different types of commercial centrifuges for this type of duty; a review of procedure for evaluating perforated basket machines for separating granular materials is also given. In the same symposium, a further paper[147] elaborates the reasons for choosing flexible and versatile equipment, including centrifuges, for these processes.

Reference has already been made to some countercurrent liquid-liquid centrifugal extractors;[44–49] general descriptions of three types have also been given by Pratt,[148] who appears to have overlooked the fact that a number of other types of machines when arranged in cascade are quite capable of performing this type of duty. The evaluation of a small-scale Podbielniak for a water-boric acid-amyl alcohol system has been reported[149] and a similar paper gives some performance data for the Luwesta type 10006 machine for an acetic acid-water-ethyl acetate system, without, however, quoting capacities.[150] These types of machines find application in the field of antibiotics and references to their use in the production of biacitracin[151] and penicillin[152–154] have been made.

Machines designed for the separation of yeast have also proved of value in recovering vitamin $B_{12}$ from broth.[155, 156] In the processing of orange juice and oil, good use is made of various types of centrifuges;[157] a Sharples DV2 machine effects a partial clarification of the screened juice and a 'Nozljector' type DM is used to break down the orange oil emulsion from the peel-treating section to give a 15 to 30% oil cream. This is then processed in a tubular supercentrifuge to give a 99% oil, and subsequently centrifuged in a De Laval, type BA, disc bowl machine to give a 99.9% pure oil. After refrigeration the oil is centrifuged once more to remove precipitated wax. Some data and experience of individual and series operation of Bird/Sharples and Bird/De Laval machines for the removal of ash and solids from oil produced by coal hydrogenation have been reported;[158] the requirement is maximum oil recovery with minimum impurity and, from limited experience, the second combination appears the most promising.



[*Alfa-Laval Co. Ltd.*

**Disc-type separator for process problems.**

Processes using ploughing basket machines include five separate treatments for the recovery and purification of mono-methyl p-aminophenol sulphate[159] and the recovery of acetylsalicylic acid.[160] Perforated baskets are used for removing ferrous chloride,[161] oxalic acid[162] and ethyl benzylanilinesulphonic acid in the manufacture of blue ink pigment.[163] Unspecified basket machines are used for the separation of ammonium nitrate,[164] lithium carbonate,[165] a uranium concentrate by-product from phosphate rock liquors,[166] ammonium sulphate from processed refinery acid sludge,[167] sodium sulphite from sodium phenate in the production of petroleum derived phenol,[168] the dehydration of prehydrolised wood and the recovery of dextrose therefrom after further hydrolysis,[169] three-stage treatment of anthracene oil to recover carbazole, anthracene and phenanthrene[170] and two-stage recovery of p-xylene.[171] A continuous solid bowl machine recovers polyvinyl alcohol and a further machine dehydrates polyvinyl butyral resin in the manufacture of the latter product.[172]

### Brewing and fermentation

There is still a divergence of opinion concerning the merits of centrifuging instead of filtration for beer clarification, and a number of critical investigations have been made. Krauss *et al.*[173] found that bacteria removal and clarification was effective by both methods but filters deteriorated after prolonged use; head retention and taste were not affected but colloid stability was lower after centrifuging. According to Narziss,[174] the latter effect is due to low capacity through the centrifuge, which causes temperature rise and subsequent increased solubility of the colloids; a high flow rate followed by filtration produces beer far superior to that produced by filtration alone. Foy,[175] after several years of experiment, has expressed some convincing points in favour of centrifuging, particularly with the modern disc-type hermetic centrifuge, which is described in some detail. It is admitted that centrifuging alone, whilst giving a brilliant beer, does not have good stability for long periods, but for normal turnover is satisfactory, particularly after enzyme treatment; subsequent sterile filtration is less costly, due to increased life of the filter sheets; quality, flavour and head formation and retention are infinitely superior to sharp filtered beer.

The treatment of beer bottoms is an important necessity, and brief reference to this and centrifuging prior to bottling have been mentioned.[176] The effect of wort clarification and cooling has been studied;[177, 178] centrifuging prior to plate cooling produced more stable and less bitter beer than the reverse operation. This was further confirmed by Wellhoener, during an investigation of turbidity formation in wort,[179] and by Scheller, who outlines the technique and advantages of centrifuging hot wort.[180, 181] The injection of sterile air into hot wort prior to centrifuging is reported to result in

economies[182, 183] and, for evaluation of head retention, only centrifuged worts, and thereby fat-free, should be compared.[184, 185]

An interesting report describing a modern British factory for yeast production gives information on the operation of De Laval machines, which are used for molasses clarification prior to fermentation and separation and washing of the product;[186–189] brief reference is also made to a similar type of plant in Sweden.[190] The use of centrifuges for the collection of cultivated algae is unlikely to be economic, but a three-stage treatment by such machines for the clarification of molasses and the concentration and washing of high-fat-content yeast is a possibility.[191] Reference has also been made to the use of yeast separators employed in a continuous fermentation process for alcohol production;[192] a patent covers a centrifugal process for the treatment of distillery slop to recover solids and an oil emulsion which is recentrifuged,[193] and a further patent relates to a yeast separator.[194]

## Petroleum and its products

On the process side little fresh information has been reported; the use of centrifuges for separating acid sludge when refining lubricating and technical white oils and liquid paraffin is fairly common practice in British refineries and brief references to this application have been made.[195–198] Further information on the potentialities of Podbielniak machines in this industry are reviewed[199, 200] and the use of two such machines for furfural refining of lubricating oil is reported.[201] Dewaxing patents include processes using ethylidene chloride, cooling and centrifuging,[202] for fractionating crude paraffin wax[203] and dewaxing hydrocarbons;[204] further patents cover the design of a continuous sludge-discharging machine with water flushing suitable for separating lime from acid refined mineral oil[205] and a process and plant for separating water from oils.[206]

A most useful paper by Clark[207] summarises modern British practice for efficient turbine oil purification; this includes references to centrifuging flushing oil in new turbines, cleaning oil systems of old machines, with special reference to the effects obtained by water washing, and maintaining the oil in good condition. The operation of centrifuges for this duty is dealt with in some detail, and a cross-section of a typical De Laval unit is shown; this equipment appears to be the most widely used type for this duty. The advent of detergent oils has given rise to some confusion in connection with their reclamation, but a short report[208] puts forward reasoned statements in favour of centrifuging; generally, clarification rather than purification is adopted, as the presence of water can cause emulsion difficulties and, in some cases, loss of additives.

The major contributions in this section cover the various aspects of centrifuging heavy fuel oil. Winberg[209] has summarised the present position in respect of diesel engines, with particular reference to water, asphaltene and ash removal and the benefits thereby obtained. The stability of centrifuged fuel oil has also received consideration,[210] from which it is believed that, whilst modern machines effectively remove impurities, the stability is not affected. Desalting of fuel oil by means of water and a demulsifying agent, followed by centrifuging, has been carried out on a laboratory scale.[211] The use of high-sulphur-content fuel gives rise to corrosion of engine crankshafts; two-stage centrifuging of the lubricating oil with water washing is recommended.[212]

Numerous installations with reference to centrifuging fuel and lubricating oil for marine diesel engines continue to appear.[213] For the most part De Laval purifier/clarifier series operated machines are employed in this now well-established procedure for treating high-viscosity fuels to make it suitable for use with this type of engine; the practice is also spreading to land installations.[214] In addition, the same principle is employed for treating fuel for gas turbines[215–217] and high-speed engines.[218] A resume of the advantages of centrifuging fuel and lubricating oil is included in a book by Southern.[219]

## Miscellaneous

*Dairy industry.* All but one of these sources are patents; the exception relates to milk from which the cream is separated, subsequently homogenised and remixed with the skim prior to flash pasteurisation to give an improved cream line when bottled.[220] The patents include a centrifuge/homogeniser arrangement for milk processing in which the separator provides a source of pressure for the homogeniser,[221] a method for the separation of cream having constant fat content,[222] a similar method particularly suitable for continuous butter production,[223] a double centrifuging operation to produce cream for butter production[224] and a further butter process involving the addition of butterfat to high-fat-content cream and centrifuging the mixture.[225]

*Starch.* Specially designed centrifuges are used for the continuous separation and washing of maize starch from gluten,[226] and a similar process is employed for potato starch.[227] A machine is suggested for final separation of oxidised starch in a new electrolytic process[228] and a patent covers a two-or-more-stage process for the continuous separation of impurities.[229]

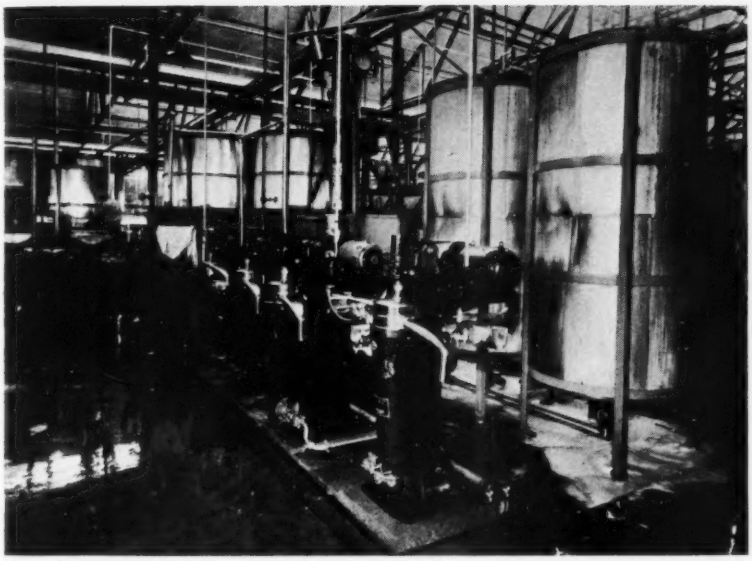
*Latex.* The addition of various salts to fresh latex followed by centrifuging has thrown some further light on the behaviour of the yellow fraction;[230] the presence of soluble magnesium salts in centrifuged latex concentrate gives rise to instability.[231] Patents cover a process for concentrating latex by creaming and centrifuging[232] and for the production of white latex.[233]

*Other applications.* For the separation of oil and sediment from coffee extracts the De Laval hermetic machine is recommended;[234] crude wool grease is centrifugally recovered;[235] the centrifugal dehydration of coal tar shows promise;[236] machines are employed for separating fine coal from coal-washing effluent;[237] solid removal and water washing by a combined chemical and centrifugal process for purifying dry cleaners' white spirit is reported;[238] lactose crystals are separated from cooled concentrated whey in the manufacture of egg albumen substitute;[239] solids are removed from air by means of a perforated truncated rotor;[240] and procedures for cleaning centrifuge bowls are given.[241, 242]

Patents include machines for oil/water separation,[243] dewatering,[244] dewatering clay[245] and minerals,[246] crystal separation,[247] precious metals,[248] liquid/solid separators[249, 250] and various other duties.[251–259] Other patents cover centrifugal separation using an auxiliary liquid,[260] a centrifugal liquid deaerator,[261] a machine with interstage washing,[262] a combined coarse/fine centrifuge installation for solid/liquid separation,[263] a centrifuge bowl[264] and bowl design to reduce abrasion.[265]

## Auxiliaries

Strain gauges measuring the torque on the conveyor drive of Bird centrifuges prevent overloading or shutdown.[266] Patents for basket machine auxiliaries cover a hydraulically operated automatic feeding device,[267] a discharge plough,[268] a discharging mechanism, controls and operating method thereof,[269] and a centrifuge mounting.[270] For other types of machines there is a sludge-level in-



**Centrifuges in the pineapple-juice processing plant of Queensland Tropical Fruit Products, Brisbane. Extracted juice from the feed tank (*left*) feeds over vibrating screens to remove coarse solids and is finally clarified in the Sharples centrifuges in the foreground.**

dicator for a centrifuge bowl,[271] a cleaner for Podbielniak countercurrent extractors,[272] a sludge valve[273] and a sealing device for feed and discharge conduits of separator bowls.[274]

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# Some Reflections on HYDRAULIC TRANSPORTATION OF COAL

By A. T. Steadman, M.INST.F., G.I.CHEM.E., A.I.MIN.E.

THE hydraulic transporation of coal belongs essentially to the province of the chemical engineer, both in concept and application. Even a primary project involving the straightforward pumping of a coal/water suspension involves several well-known unit operations, whilst more ambitious ideas, and possible future tie-ups with coal preparation and water clarification, place it well in the chemical engineering field. This is a further instance of the scope for young chemical engineers in the coal industry.

Although the pumping of coal through pipelines is not a new idea, its serious consideration as a means of transporting coal is new, and the possibility is being fully investigated at the present time. Reasons for this interest include such factors as transport costs and miners' occupational diseases, plus other hazards.

### Earlier applications

Hydraulic transportation has been used as a means of transporting solid material for a large number of years without any thought being given to its adaptation to the moving of coal. In America and Canada, aqueducts and troughs have been used for several years in the moving of ores and minerals of varying size from slimes size up to several inches. In Britain the old-established method of moving white clay, in Cornwall, was by means of open channels or launders; some of these old constructions are still in existence at disused china-clay mines.

Sand and shingles have been moved in large quantities in various parts of the world, including Great Britain, especially in the making up of beaches worn away by coastal erosion.

More recently (1913) a coal-pumping scheme was operated in London; coal being pumped a distance of 660 yds. through an 8-in. pipe from barges on the Thames to the Hammersmith power station. This installation operated for some ten years or so, but difficulties, owing to lack of hydromechanical data, doomed it to failure. More recently still, at Markham colliery in Derbyshire, a pilot-plant pumping station, with a 300-yd. pipe, pumps 30 tons/hr. of 3-in. coal.

In Canada a 2,000-ft. pipeline delivers 120 tons/hr. of 5- to 0-in. crushed rock, using an 18-in. pump. A more ambitious scheme, working today in France, pumps fine coal from a coal preparation plant to a power station through a 15-in. pipeline a distance of 5¼ miles. Many other instances could be quoted, but in nearly all these cases of earlier applications the job was easy and the distances relatively short.

The movement of solids other than coal is obviously limited by the physical and chemical characteristic of that solid; even with some types of coal, hydraulic transportation will affect the final physical characteristics, especially with dry brittle coals which will absorb moisture and break up, becoming degraded. Run-of-mine coal contains dirt, the character of which varies according to the particular strata from which it is mined; clays which normally stay solid will be washed off the coal by the water and remain in suspension. This particular condition might have a large influence in the efficiency of coal pumping in some coal fields and would most certainly make it necessary to have water clarification plant incorporated in the system.

We must not overlook the fact that the overall costs of transporting coal and dirt from coal face to consumer must represent an appreciable percentage of the total amount of coal mined; statistics for this would show up best if given in therms.

### Present experiments

The reasons for apparent neglect of hydraulic transportation in the past are various; the main one is probably economic, combined with lack of demand, cheap labour and a smaller population. In the days of smaller industries there was no call for the rapid transport of coal, and in the period before mine mechanisation the incidence of miners' diseases, owing to dust, was low.

The following are the usual methods of coal transportation that are practised today.

**Underground transportation:** (1) Mine cars—pulled by endless rope, steam or electric prime mover. (2) Tubs—pulled by ponies (now little used). (3) Conveyor belts—electric motors (the most usual method).

**Underground to surface:** (1) Mine cars—elevated to surface by winding machinery. (2) Containers—elevated by winders.

**Surface transportation:** Mine cars, bucket elevators, conveyors, skips and wagons.

**Transportation outside the mine:** Rail transport, road transport and barges.

It will be obvious that transport, overall, is the largest factor influencing the price of coal to the consumer, being of course intermediate between getting and cleaning, and cleaning and using. Whilst transport costs generally have always been a big factor, the increase has been a progressive one owing to increasing wage demands and other factors.

The growing interest and experimentation in hydraulic transportation is due to the demand for cheaper and easier transport. When schemes now envisaged have been applied we can also expect the reduction, if not complete elimination, of miners' lung diseases such as pneumoconiosis, which has increased with mine mechanisation. An important hazard is the liberation of dust at loader points on underground belt-conveyor and mine-car systems.

Experimental work is being carried out by the British Hydromechanics Research at Harlow on laboratory and pilot-plant scale; this work is largely at the instigation of the National Coal Board. The N.C.B. themselves are also doing large pilot-plant work, of which the one referred to at Markham colliery is an example. A further trial on plant scale is being made in Scotland.

## Engineering aspects

The present research will, of course, decide the future primary types of equipment necessary for hydraulic transportation in the matter of feeders, pipeline and pumps and the ancillary equipment that is essential to any system. Attention is drawn to the fact that, in the majority of existing or past methods of solids pumping, the solid is conveyed in small particles which actually pass through the pump itself. In the case of a centrifugal pump these solids pass, with the liquid, through the eye of an impellor, and are flung outward to the shroud of the pump before leaving the outlet and travelling at a predetermined velocity along the pipeline.

Pumps now working on dredging operations are handling stones up to 5 in. across and having a specific gravity much greater than that of coal itself.

By passing coal through a pump we obtain what might be termed true hydraulic transportation; however, present research in design is based on handling large run-of-mine coal, or coal at least, say, 8 to 12 in. in size, and pumps to pass pieces this size would be enormous and costly. The large dredge pumps in use today are extremely heavy and costly items—for example, a pump working on the Beauharnois power canal in Canada is 18 in. in diameter and uses 1,500 h.p. to handle 120 tons/hr. of crushed rock of 5 to 0 in. through a 2,000-ft. pipeline.

Hydraulic transportation does not mean that all the material will be 'pumped' in the literal sense; we can employ booster pumps and pump the coal indirectly along and up pipework. Velocity of flow is maintained by means of these external booster pumps located at predetermined points along the pipeline, the initial velocity being provided by means of a main feed pump at the coal-feed end.

Probably the greatest difficulty at the moment is the design of a feeder suitable for feeding the coal from, say, a hopper or other container into a pipeline. It will be appreciated that the pressure of water in an hydraulic pipeline may be up to 1,000 p.s.i. Coal must be admitted against this head. We shall probably have, though, two systems of coal pumping: low-pressure and high-pressure. In the low-pressure pumping system the feeder itself could be sufficient to push the coal along, depending on the distance and the hydraulic head. In the high-pressure transport line a feeder has been devised which is intermittent in action; a double-acting piston feeder pushes unit batches of the material into the pipeline. At the instant of each injection the feeder becomes part of the high-pressure line —that is, half of the feeder; the second half comes on when the first half is taken off the pressure pipeline and back to the atmospheric pressure of the container. It is not possible to give details of any particular feeder at the moment as the designs are only in the initial and trial stages, but it does seem reasonable to expect that an intermittent injection system will be adopted, the most suitable method being the subject of patent rights.

In the method of coal transportation now being studied it is desirable to design plant to handle coal up to, say, 12-in. size. The main consumer of large, hard coal is the railways and, with existing locomotive firebox design, large coal is essential. However, recent Government proposals for replacing steam locomotives with diesel engines and ultimately complete electrification will mean that more coal-to-oil plants will be built and also more power stations. Both types of consumers require small coal. Proposals to make all domestic users of fuel burn a smokeless fuel, if effective, would further reduce the demand for large coal and increase, again, the demand for small coal for domestic coke and semi-coke manufacture.

At the coal face, then, we can envisage portable crushing plant for reducing the newly won coal down to an optimum size preparatory to loading it into a hopper or bunker—the bunker would be necessary to act as a surge between the crusher and the pipeline feeder. The feeder can almost be regarded as a kind of non-return valve between coal getting and coal transportation.

## Direct pumping

Pumps would fall into two main categories:

(1) Single-stage or two-stage, non-clogging pumps to be used when the coal actually passes through the pump itself.

(2) Multi-stage high-pressure pumps or turbine pumps. These would be booster pumps handling water only, and injecting velocity, in the form of water, into the pipeline.

In the case of direct pumping, when the coal is handled by the pump impellor itself, we can assume the use of pumps designed for a static head of, say, 10 ft. up to 125 or 150 ft. and having a capacity of 10 to 150 gal./min. in pipes of up to 8-in. diameter. Depending upon the size of the pieces of material, these pumps may have to be fitted with impellors cut down, which will facilitate pumping but reduce the overall efficiency of the pump set. A variety of factors will influence the design of pumps for handling coal above, say, $\frac{1}{4}$ in. This size is handled now in existing types of slurry and 'washery' pumps, the material of fabrication of the impellor and casing, the speed of the pump and the diameter of the inlet and outlet being chief factors.

The ratio of solid to liquid is also, obviously, a factor of prime importance and, whilst the ratio 1: 6 has been suggested, it does not follow that this ratio will do for all sizes and densities of coal and for all velocities. However, we can say that the proportion of coal to water will be somewhere in the range 1: 5 to 1: 8.

## Booster pumps

In the case of booster pumps, the capacity and head of the pump will be entirely influenced by the transportation requirements in respect of:

(*a*) Gal./min. of water and lb./min. of solids.

(*b*) Size of solids.

(*c*) Static head } Total static

(*d*) Distance } pumping head.

Pumps in the high-pressure range may have speeds up to 3,500 r.p.m. with capacities up to 2,000 gal./min., or heads up to, say, 2,000 ft. They may have branches up to 12 in. and be built in stages of up to eight or twelve. Almost any kind of pump can be used for a booster pump providing it will do the work required. Obviously, however, the pump specially designed for high pressure will have the highest efficiency relative to cost.

Whilst we assume the use of centrifugal pumps in hydraulic transportation, we should not forget that for maximum positive pressures, in fact pressures only limited by the strength of pipework and connections, the piston-type positive displacement pump is still the most suitable pump and may be used along with a feeder, when feeding is by removal of water from the pipe and then returning with the water-coal mixture. Piston pumps could not, however, be used for direct pumping of water-coal mixtures.

The use of a reciprocating pump in vertical boost, *e.g.* from the pit bottom up a mine shaft, might be a better proposition than a centrifugal pump, whether pumping direct or by-passing and using a special feeder.

## Pipework

The pipework employed in hydraulic transportation is important, especially from the point of view of wear and tear. Abrasion must be considered, and also mechanical finish inside the pipe. Bends, especially, must be smooth and free from malformations, lumps and blowholes; high-speed eddies may be caused on high-velocity pipelines, which could become progressively worse, causing permanent damage to the pipeline at that particular point. Pipework may be heavy-duty for permanent installations and therefore must be of good mechanical quality. In many cases, especially underground, pipework will be in standard, suitable lengths in much the same way as conveyors are at present. Whilst pipework in this class will still have to be strong and resistant to abrasion, it will have to be lightweight and in suitable lengths for moving about, say, underground. Experience in pumping sands and gravels shows high internal wear due to the hardness factor of the solids being pumped. Coal is much softer than, say, gravel and can be self-lubricating, but at its own expense, with the result that we obtain degradation, especially in the initial stages of pumping, *i.e.* degradation will take place progressively along the length of pipework. The fines produced will tend to fall to the bottom of the pipe, thereby silting it up, which means that in long-distance systems the speed of flow may become progressively so slow that it will have to be stepped up from booster to booster.

This means a still higher rate of degradation—a vicious circle in fact; therefore the sum total of all degradation produced in a pipeline of unit length will be a cumulative one and may, apart from being serious, increase the economies of a scheme. On short-distance runs, such as the N.C.B. have experimented with so far, the degradation has not been a serious factor, and it must be difficult, without some specific tests to prove it, to assess the final consequences of coal breakage. It should be borne in mind, too, that best bituminous coals will give a higher rate of degradation than hards or steam coals. Apart from the smooth finish desirable in pipes, the bends must not be too sharp; nothing over 90° should be considered.

Another factor, especially on long-distance surface-pumping installations, will be the need for protection from freezing and also from mechanical damage due to traffic, etc., when pipes run under roads, railways, etc.

## Colliery applications

The primary use of hydraulic transportation of coal will be at collieries and the method will be applied as follows:

(*a*) Transportation from the coal face to the shaft.
(*b*) Transportation of the run-of-mine coal up the shaft.
(*c*) Transportation of the run-of-mine coal to coal preparation plant.
(*d*) Transportation of clean coal to wagons, and dirt to dirt-tip.

The ideal sought for would combine all the above applications, and modifications to suit particular conditions.

We shall have to assume that material moved from the coal face is all –12 in. There seems a possibility that stratification of at least the pure dirt from pure coal could take place in a washer situated at the pit bottom, the coal only would then have to be sent up the shaft. One can visualise a type of trough washer as a continuation of the pipework, separating the run-of-mine coal into coal and dirt. The coal would contain the middlings fraction and the dirt would be sent back to the coal face to be used for stowage, *i.e.* packing.

After dewatering, a system such as this would work on a closed circuit, as far as the water was concerned, except for the incidence of fines in the water, which means that some kind of water clarification plant would be required. The water clarification plant would probably be more suitably situated on the surface, in which case the washed coal would go up the shaft along with all the water originally employed in underground transport and cleaning. Clean water returning down the shaft would carry the dirt back to the coal face. If cleaning did not take place, and no stowage, the system of clean water return down the shaft would still be applicable and, indeed, an essential part of the transport process.

In the case of collieries with long distances from the face to the shaft, it would be possible to take out boreholes located near the working face and pump the coal up the bore and save the long distance of horizontal transportation.

Friction losses and drag, it will be appreciated, will be less for vertical pumping than for horizontal. With horizontal pumping the tendency towards stratification of the coal and dirt, and settlement of degraded shale, will always have to be overcome.

The possibility of vertical borehole take-offs located near the coal face itself has been mentioned by a few people recently; the only thing against it, apart from cost and the obvious snags to sinking holes on private property, is that a coal face is moving all the time, which means that the coal-cleaning plant will have to be portable, otherwise the pipework will have to be extended both above and below ground to match up with the points of work.

At collieries which have existing coal preparation plants it can be expected that these will be used to clean the coal after the coal has been dewatered, or possibly dewatered and screened.

The water clarification plant, too, will be an important unit at most collieries, especially where water is scarce. Depending upon the ash content of the solids in the water, we should anticipate the use of either flocculation or froth flotation units.

When the ash content is very high, especially in the coarser particles, the water would be clarified by simple flocculation methods in thickeners and the solids disposed of. If, however, the coal content of the fines in the water was high, or the rank of the coal made recovery valuable such as in the case of coking coal, then a froth flotation unit would, no doubt, be used.

The size and type of water clarification equipment would depend entirely upon the degradation products; in some cases a high amount of dirt fines would be made, whilst with very soft bituminous coals, and when the dirt was hard, the degradation products might be a high-ash coal with low total ash content—in this case we could recover by flocculation and use the fines direct as a boiler fuel or for the manufacture of briquettes, or even for blending with washed coal for power station use.

One annoying disadvantage of mechanical mining is the disposal of fine dirt produced, known as ' gummings,' when the coal is cut. Normally, in good mining practice, the cut is made below the coal itself, preferably into the pure dirt. At some collieries, owing to the character of the strata, the cut is made as far away from the marketable coal as possible in what is often referred to as ' jacks '—this is a homogeneous mixture of coal and dirt or simply high-ash coal. An appreciable amount of these gummings are produced and one can visualise the difficulty of disposal in a system of hydraulic transport already predetermined as regards velocity, etc., for a particular size classification of run-of-mine coal.

(*Concluded on page* 194)

# The Production of Fresh Water from Salt or Brackish Water

**By J. Leicester, M.I.CHEM.E., A.I.MAR.E.**
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*An important use for chemical engineering knowledge at sea is in the demineralisation of sea water. However, Royal Naval research on the de-salting of brackish or salty water by evaporation is of benefit not only to sailors and shipping companies but also to industrial and domestic users in countries where water supplies are scarce. The author describes some recent advances.*

## Introduction

A BATTLESHIP requires some 350 tons/day of fresh water to satisfy the needs of the ship's complement and to make up water losses in the boiler circuits. There is only one way of meeting this requirement. The fresh water must be produced by boiling the sea water in an evaporator plant and condensing the vapour to form the required distilled water, whilst discharging overboard the concentrated sea water or brine from the shell of the evaporator to maintain a convenient working density.

During the last war, when ships had to remain at sea for long periods, it was becoming increasingly obvious that the efficiency of evaporators of existing design would have to be improved considerably to meet with the increased water demands. The position has been further aggravated during the post-war years by a definite tendency towards raising the habitability standards in H.M. ships, which has resulted in a considerable increase in the quantity of fresh water used for domestic purposes.

In conjunction with the Engineer-in-Chief of the Fleet's Department of the Admiralty it is in this field of chemical engineering that the Royal Naval Scientific Service has been able to play a major role in the development of feedwater treatments for scale prevention and improved efficiency in evaporators of existing design. Development of new design evaporating plant having higher thermal efficiencies and also the development of alternative methods of sea-water purification, are the concern of our immediate experimental programme.

It is the aim of the present article to survey the past, present and future trends of fresh-water production and to illustrate how the efforts of the R.N.S.S. have helped to provide the sailor afloat with a supply of fresh water the equal of that of his colleage on land, how the efficiency of the fighting ship has been improved and, what is even more important, how the money spent on scientific research has repaid handsome dividends through improved operating efficiency and reduced cost of the water produced.

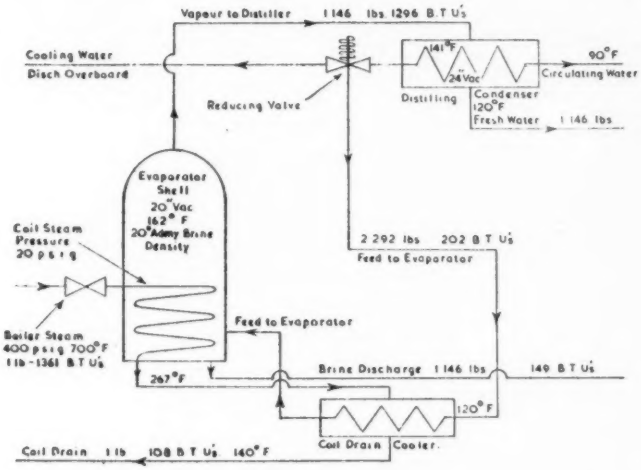



**Fig. 1. Single-effect evaporator.**

## Conventional types of distilling plant

A single-effect distilling plant can be said to consist primarily of two heat exchangers, namely:

(1) The evaporator, in which heat is supplied to the sea water and which converts some of this water into steam (or vapour) leaving salt impurities behind in the residual brine.

(2) The distiller condenser, in which heat is taken from the vapour which is thereby reconverted into distilled water.

All the other parts of the plant such as pumps, valves, feed heaters, etc., are supplementary to these two main components and are fitted either to enable them to perform their correct function or to increase the operating efficiency of the plant. Throughout this article the term 'vapour' is used to signify the steam air mixture released from the boiling brine and the term 'brine' refers to the concentrated sea water in the evaporator shell.

The single-effect evaporator possesses one shell only. Heating steam passes through a series of heating coils where it condenses and gives up its latent heat of condensation to the surrounding brine, a proportion of which is converted to vapour. The vapour then passes out to the distiller condenser where it condenses to form the product, distilled water. A typical flow diagram for a single-effect plant is shown in Fig. 1. The vapour pressure in the shell can be either above, at or below atmospheric, according to the pressure of the heating steam available and the necessity for maintaining a temperature differential of about 70°F. between that of the heating steam and the brine boiling temperature.

The multiple-effect evaporator is merely a number of single-effect units

operated in series, but instead of the vapour from the first effect passing directly to the distiller condenser, it passes to the heating coils of the second effect, and so on throughout the number of effects that may be in use. The vapour from the last effect passes straight out to the conventional distiller condenser. A flowsheet for a double-effect plant is shown in Fig. 2. The shell pressure or vacuum decreases in each effect to maintain the desired temperature differential between brine and heating steam. The choice of single- or multiple-effect evaporation depends upon a number of factors, the main ones being the initial pressure of heating steam available, the average daily output required and the space available for the plant. In general, the cost of water produced by a multiple-effect evaporator is less than that from a similar capacity single-effect plant, but this is offset by the increased size of the multiple-effect evaporator. Thus, for marine installations, where size and weight of plant are major considerations, single- or double-effect evaporators are preferred. In land power station installations, where cost is a more important consideration than space, it is found that quadruple and even sextuple plants are quite common.

Another design of conventional evaporator, the forced-circulation flash evaporator with a steam thermocompressor, is in quite common use in land power stations, but is not favoured for marine use. A schematic flowsheet illustrating this type of evaporator is given in Fig. 3. The main advantage claimed is increased thermal efficiency coupled with reduced cost per ton of distilled water. However, to achieve this, the plant becomes more complicated and, what is even more important, the present design of heater with brine inside the tubes is very prone to scale formation from the concentrated brine. Once scaled up, this heater is very difficult to clean on board ship.

## Scale formation and evaporator efficiency

On an average 1 ton of sea water contains about 70 lb. of dissolved salts consisting almost entirely of the chlorides, sulphates and bicarbonates of sodium, calcium and magnesium. Sodium chloride accounts for about 78% of these salts, and calcium and magnesium 1.2% and 3.7% respectively. Under evaporator operating conditions, sodium chloride forms little or no scale due to its high solubility, whereas calcium and magnesium deposit scale due to the formation of insoluble compounds. This scale deposit consists mainly of calcium carbonate, magnesium hydroxide and calcium sulphate. The proportion in which these compounds appear in the scale, their crystalline form, texture, hardness and resistance to heat transfer largely depends upon operating conditions and may show considerable variation.

**Table I. Scale Formation in Evaporators—Effect of Various Operating Conditions**

| *Evaporator shell pressure* | *Brine boiling temperature* | *Brine density (sea water = 10° Admy.)* | *Coil (heating) steam pressure* | *Composition of scale formed* |
|---|---|---|---|---|
| Vacuum | Below 212°F. | Low 15° Admy. | Low (4-15 p.s.i.g.) | Mainly calcium carbonate |
| Vacuum | Below 212°F. | High 30° Admy. | Low (4-15 p.s.i.g.) | 80% Calcium carbonate<br>20% Calcium sulphate |
| Atmospheric | 212°F. | Low 15° Admy. | Medium (16-28 p.s.i.g.) | 80% Calcium carbonate<br>20% Magnesium hydroxide |
| Atmospheric | 212°F. | High 30° Admy. | Medium (16-28 p.s.i.g.) | 60% Calcium carbonate<br>20% Magnesium hydroxide<br>20% Calcium sulphate |
| Pressure | Above 212°F. | Low 15° Admy. | High (29-60 p.s.i.g.) | 50% Calcium carbonate<br>40% Magnesium hydroxide<br>10% Calcium sulphate |
| Pressure | Above 212°F. | High 30° Admy. | High (29-60 p.s.i.g.) | 30% Calcium carbonate<br>20% Magnesium hydroxide<br>50% Calcium sulphate |

As evaporation proceeds, the concentration of solids in the brine increases up to the point at which the brine density is normally maintained (equivalent to a concentration twice that of sea water, *i.e.* 20° Admy.) and when the concentration of any particular salt exceeds its solubility under these prevailing conditions, it crystallises out of solution. When a bubble of steam is formed on an evaporating surface, the salts contained in the surrounding water concentrate in a thin liquid layer around the bubble periphery where this is in contact with the metal surface. This surface, in contact with the vapour in the bubble, becomes slightly superheated and the extra heat causes increased evaporation at the contact edges of the bubble. If the liquid at this point is saturated, *e.g.* with respect to calcium sulphate, then the increased evaporation produces supersaturation and an irregular ring of calcium sulphate crystals will be deposited. If, after a bubble is released from the evaporating surface, water unsaturated with respect to calcium sulphate replaces it, the crystals will redissolve, but if saturated water replaces the bubble, they will continue to grow and so scale will gradually build up on the heating surface.

Some of the magnesium and calcium in solution in sea water is in the form of magnesium and calcium bicarbonate. When the water is boiled, carbon dioxide is driven off and the bicarbonates are converted into carbonates. Calcium carbonate is insoluble, but magnesium carbonate is soluble and further boiling gradually converts it into an extremely insoluble compound, magnesium hydroxide. This compound, together with the calcium carbonate, forms the basis of most evaporator scales. These reactions may be indicated as follows:

$$(1)\ Mg(HCO_3)_2 = MgCO_3 + CO_2\uparrow + H_2O$$

$$(2)\ MgCO_3 + H_2O = Mg(OH)_2 + CO_2\uparrow$$

$$(3)\ Ca(HCO_3)_2 = CaCO_3 + CO_2\uparrow + H_2O$$

As previously mentioned, the composition of the scale formed at the heating surface is mainly dependent on the conditions under which the evaporator is operated. Table I spans the cause and effect of major variations in operating procedure.

It will be seen that for any feedwater treatment to be successful it must be effective whether the scale is composed mainly of calcium carbonate, or of a mixture of calcium carbonate with magnesium hydroxide and/or calcium sulphate.

From the weight of the solid potential scale-forming material present in the concentrated brine it will be obvious that scale formation in an evaporator handling some 10 tons/hr. of sea-water feed is likely to be considerable. With untreated sea water it is quite common during a 500- to 600-hr. operating period for a hard adherent scale layer $\frac{1}{4}$-in. thick to form

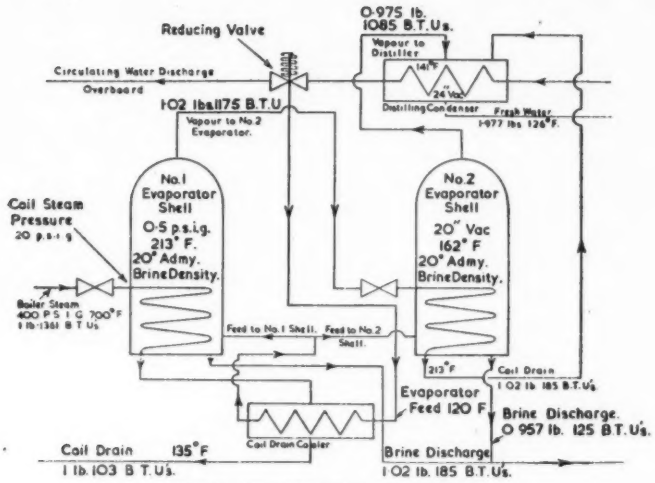



**Fig. 2. Double-effect evaporator.**

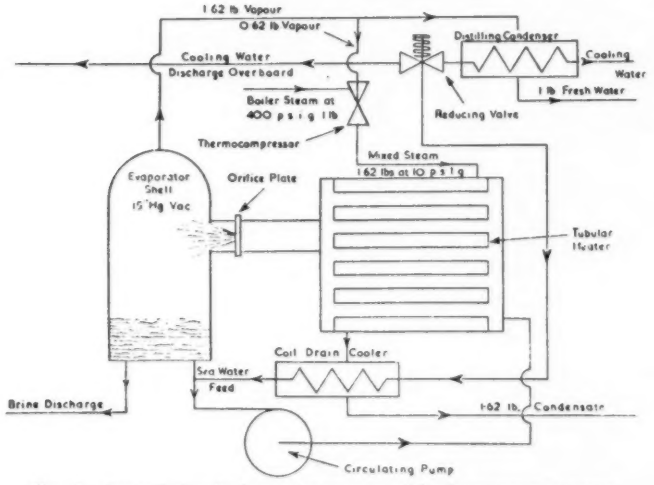



**Fig. 3. Forced-circulation evaporator with thermocompressor.**

over the entire heating surface. This results in a considerable loss of efficiency, because the layer of scale imposes a very serious resistance to heat flow. Taking as average an overall heat-transfer value of 900 B.Th.U./hr./sq.ft./°F. in an evaporator with clean copper heating coils, the formation of scale over a 500-hr. operating period can reduce this value to as low as 300 B.Th.U. hr./sq.ft./°F. with the obvious associated drop in the output of distilled water per square foot of heating surface.

## Effects of foam formation

Sea water entering the evaporator shell is brought into contact with the steam-heated coil surface and rapidly reaches the temperature of boiling. When pure water is boiled the bubbles of steam rise to the surface and burst. However, when a brine solution containing much dissolved solid matter and possibly including traces of organic matter is boiled, foam is formed on the surface of the liquid and, if the rate of vapour generation is sufficient, the whole becomes a foaming mass in which it is impossible to define the precise point of separation between brine and foam. It will be appreciated, therefore, that control of the foam level becomes a very difficult matter, because the false head of foam does not register as a true level in the gauge glass. It can only be controlled by direct observation through the sight glass in the side of the evaporator shell.

As the vapour is released from the foam surface, large masses of brine are thrown upwards, and these break into droplets of varying mass and diameter. The height to which these droplets are projected is directly related to the rate of vapour release from the foam surface. If the evaporator design is such that there is sufficient height between foam surface and the entrance to the baffle, no brine particles will reach the baffle by direct splashing. However, once each splash has broken up, the individual droplets then come under the influence of the velocity of the vapour passing up the shell of the evaporator. Particles above a given size will, due to their mass, drop back into the brine; whereas particles of smaller mass will be entrained in the vapour stream and pass upwards into the baffle. A proportion of these small particles may pass through the baffle and into the condenser; this is known as carry-over. It will be ovious that for a given brine density in the evaporator the salinity of the made water (distillate) will be directly proportional to carry-over.

From the previous remarks it will be seen, therefore, that two main conditions must be fulfilled to obtain water of a given purity:

(1) There must be a definite minimum height between the surface of the foam and the entrance to the baffle.

(2) The velocity of the vapour passing up the shell has a definite optimum value which must not be exceeded if carry-over of particles of the solid is to be prevented.

In general, if the height between the foam surface and the baffle is not adequate, sudden and irregular priming will occur, whereas if the vapour velocity becomes too great a definite and fixed increase in the salinity of the made water will result.

In the majority of cases these two parameters will be fixed in the design of the evaporator, and it is not always possible to undertake mechanical modifications of a plant to increase the height between foam surface and the inside of the baffle. It will be shown later, however, how this effect can be achieved by the use of a feed-water additive. One particular example will be the effect of an anti-foam compound in reducing considerably the head of foam on the boiling brine and thereby increasing this height safety factor between brine level and the inside of the baffle. The net result will be to increase the heating surface immersed in the boiling brine and thereby to increase the output of distilled water from a given plant, whilst maintaining a high standard of purity.

## Feedwater treatments

The feedwater treatment in use by

the Royal Navy during the last war was adapted from the Navy boiler compound/starch mixtures developed for the U.S. Navy by Rear-Admiral T. A. Solberg. This treatment was partly chemical and partly surface active in its action. The Navy boiler compound consisted of a mixture of sodium carbonate 40%, di-sodium phosphate 47% and corn starch 13%. The complete treatment involved the addition of 10 oz. of the above mixture, plus an additional 20 oz. of corn starch, to 10 tons of sea-water feed.

Whilst undoubtedly this treatment when used correctly did to a degree reduce and control scale formation, the results obtained in general throughout H.M. Fleet were not satisfactory, hence the development of the present *Admiralty Evaporator Compound*. The earlier treatment did not give complete chemical control of scale-forming material, nor did the corn starch act as an efficient colloidal treatment for the modification of the physical character of the scale-forming solids. This was mainly due to practical difficulties in the mixing on board ship of the starch in boiling water to obtain a completely hydrolysed solution. Too often the starch was added in the form of a partially hydrolysed slurry which aggravated rather than eased the scaling problem. It is also obvious that, to obtain adequate chemical control, stoichiometric proportions of feedwater additives must be used. When the weight of scale-forming matter passing into the evaporator is considered, it will be realised that stowage of the chemicals required is a major obstacle.

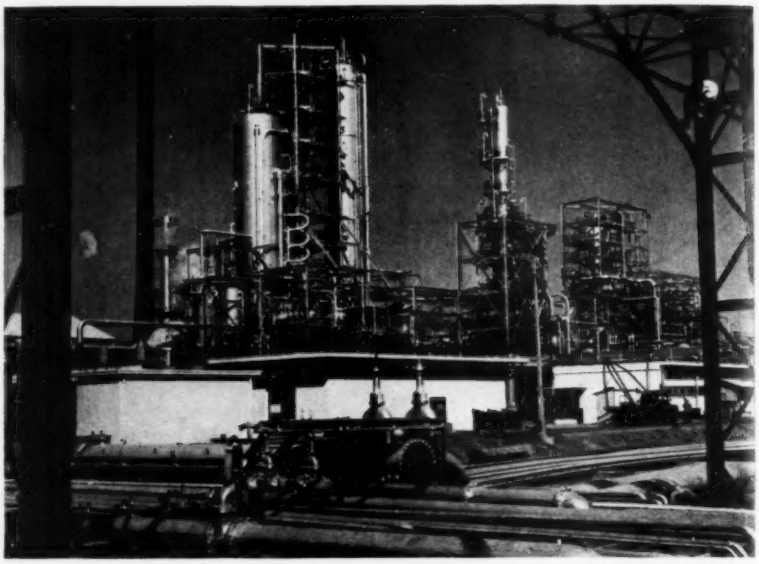
**Acknowledgment**

Thanks are due to the Chief of Naval Information for enabling this information to appear in this journal.

*A continuation of the above article will appear in a forthcoming issue of* CHEMICAL & PROCESS ENGINEERING. *This will go on to deal with the various feedwater treatments that have been developed, the results that have been achieved with them and the savings that have been effected in H.M. ships. There will also be some discussion of the type of evaporation equipment likely to find favour in the future, and also of other methods of sea-water purification, such as ion exchange and electrodialysis.*

**Scientific instruments.** The new W. G. Pye catalogue 'J' supersedes all previous issues and, while several important additions are included, contains only those instruments in current production. (26 pages, illustrated.)

# India's Largest Refinery Completed Ahead of Schedule



**Crude distillation unit (*left*) and feed preparation unit (*right*) of India's largest refinery, newly completed, on Trombay Island.**

THE largest oil refinery in India, built near Bombay by Burmah-Shell Refineries Ltd. at a cost of over £23 million and completed a year ahead of schedule, was formally opened recently. Situated on Trombay Island, 10 miles to the north-east of Bombay, the refinery, which incorporates the most modern equipment, will process 2 million tons p.a. of crude oil. Its production of petrol, kerosine, diesel oils and furnace oils will be the highest in India. In addition it will also produce the greater part of the country's bitumen requirements.

The initial planning and investigation work for the refinery began in 1952 and, despite early difficulties, the 450-acre site was acquired in 1953. Within 18 months a labour force, which at its peak numbered 14,000, converted the marshy land into a busy refinery. Some 60,000 tons of steel have been erected, 40,000 cu. yds. of concrete poured, 12 miles of road built and 200 miles of electric cable and wiring laid; 800,000 cu. yds. of earth were used to fill up low-lying areas on the site.

A well-equipped laboratory to test refined products is now complete and is run almost entirely by Indian personnel.

Amenities for labour include a modern two-storey canteen and a well-equipped medical centre. In addition, £300,000 has been contributed to the cost of building, by the Bombay Government, housing for about 500 workers and their families within a short distance of the refinery site.

To provide staff for higher technical positions, arrangements were made for 29 Indian trainees, after preliminary training at the Assam Oil Co.'s Digboi refinery, Assam, to visit the U.K. and Europe for nine months' to a year's training in Shell refineries and a further 20 received practical training on site during the construction work. In addition a total of 200 Indians, who will be responsible for operating different refinery units, were instructed in the detailed technique of modern plant processes.

**Canadian fish-meal plant**

For their new fish-processing plant at Gaspe, Quebec United Fishermen have placed an order with Power-Gas Canada Ltd., of Montreal, for the supply of a complete Rosedowns fish meal plant.

This plant will be of advanced design and fully continuous in operation, producing a high-protein meal from up to 5 short tons hr. of oily and non-oily fish and fish offal. The plant will be installed during the fall and it is hoped to carry out trial operations before the end of this year's fishing.

Power-Gas Canada Ltd. is an associate company of the Hull firm of Rose, Downs & Thompson Ltd.

## Conference on

# THE FUNCTIONS AND EDUCATION OF THE CHEMICAL ENGINEER IN EUROPE

**Is chemical engineering a science or an art? Does the term 'chemical engineer' cover one distinct job, or can it apply to any one of a number of different workers? Because, in Germany, they have found that 'process engineers' fit in better with the scheme of things there than 'chemical engineers' as they are understood in America, Britain and elsewhere, must there necessarily be disagreement about the development of training and research facilities in Europe? How useful are pilot plants? Where should theoretical training end and practical training begin? These and a host of other interesting questions were discussed at a conference held in London recently. Eminent authorities from 17 different countries presented papers and exchanged views on what chemical engineers were for, how they should be trained, and how chemical engineering research should be carried out. The conference was aimed at drawing attention to the need for more chemical engineers and for more chemical engineering research, and to help spread the recognition that chemical engineering has an extremely important part to play in modern industry. The conference was organised by the Institution of Chemical Engineers in co-operation with the Department of Scientific and Industrial Research for the European Productivity Agency of the Organisation for European Economic Co-operation. The meetings lasted three days, during which six sessions were held. Here we present the first half of our report on the conference, in the form of extracts or summaries of the papers presented together with the discussion which ended each session.**

THE conference was opened by the Lord President of the Council (Lord Salisbury), who recalled how, less than 75 years ago, a certain lecturer in chemistry at the Manchester College of Technology, Mr. George Davis, had realised the need for another basic engineering technology, which he had called 'chemical engineering,' and he had given the name 'A Handbook of Chemical Engineering' to the book of lectures he had published in 1901. But the subsequent history of that particular technology was, unfortunately, so far as Britain was concerned, rather similar to that in a good many other fields. Davis had been years before his time here and his vision had first found expression in the United States.

The present conference arose directly from the report of the Technical Assistance Mission of the O.E.E.C., which had made a special study in the United States. The main conclusion of the report was that the dominant position in the chemical industry which the United States occupied today was due largely to the rapid development of the profession of chemical engineering there and the recognition of its value by the American Government, by industry and by the universities. That fact underlined, if it needed underlining, the importance of the subject of the conference at this time of rapid growth of the chemical industry and the important applications which chemical engineering was finding to so many industries.

Calling attention to a few of these, Lord Salisbury mentioned the preparation of fuels, which were the basis of our power production; the conservation and preservation of food by food processing, which was becoming very much a major industry; the scientific processing of raw materials to meet world demands, in which the help of chemical engineering was essential; the development of plastics and synthetic fibres; and the vast field of atomic energy, where the chemical engineer was playing an essential part in the main developments that were taking place.

The conference would first discuss the varying fields of activity covered by the chemical engineer, and he had not the slightest doubt that the experience of all the countries represented would provide a most valuable background against which to consider later the best method of training those engineers. He imagined those methods would differ, since they had to be fitted into the various educational systems of the various countries, but he hoped the final result would help us all in the provision of a class of men who were in such great and growing demand.

### FIRST SESSION

*Chairman: Sir Harold Hartley*, K.C.V.O., C.B.E., M.C., D.C.L., F.R.S. (*President, Institution of Chemical Engineers*)

'The Part Played by the Chemical Engineer in Bridging the Gap between Research and Plant Construction,' by Sir Christopher Hinton, F.R.S. (managing director, Industrial Group, United Kingdom Atomic Energy Authority).

We have a series of people working on the design of a process plant, merging from the pure scientist, at one end, who need have little or no knowledge of plant design and plant operation, to the detailing mechanical engineering designer at the other end of the scale, who need have little knowledge of the scientific principles which underlie the process. No hard and fast line can be drawn between the various types of scientists, 'chemical engineers,' and engineers, who fit into the pattern between these two extremes. They merge into one another like the bands of a spectrum and almost all of them have at one time or another been referred to as chemical engineers.

The foregoing applies to the typical team for the design of any process plant and not, more narrowly, the typical team for the design of a chemical plant. The profession of chemical engineering is now so well established that it is probably not possible to consider changing its title, but we must beware that the narrowness of this title does not blind us to the fact that exactly the same principles apply in the design of all process plants, whether the underlying scientific principles are those of chemistry or of classical physics or of nuclear physics or of metallurgy.

A realisation of this fact makes clear the standing of chemical engineering and the need for adequate facilities for the training of chemical engineers. Engineering is an art, but it is an art which has firm foundations on the physical sciences—you only learn engineering on the shop floor. What we should expect our universities and technical colleges to do is, not to teach the whole art of engineering, but to teach the scientific principles on which this art is based and to show how these principles are applied in various branches of the art.

The development of atomic energy is going to be of great importance in the coming years, and it is essential that the universities should be turning out men who have a suitable theoretical training to give them an understanding of the underlying theory of nuclear reactors and to enable them quickly to grasp the technologies of design.

In the spectrum of scientists, technologists and engineers already referred to, the chemical engineers, as the term is usually understood, are those who are engaged in devising the plant flowsheet and who, when pilot plants are necessary, are responsible for designing and operating those pilot plants in order to determine the dimensions which will be needed in the full-scale design.

The construction and operation of pilot plants tends to be overdone. It has been a frequent experience with atomic energy plants that they could be designed and put into operation without any trouble, without the need for a pilot plant. However, this procedure can only be followed when the characteristics of the unit operations which it is proposed to employ have already been established, either by chemical engineering research or by actual operating experience of such unit operations in other processes.

On the question of how best to train an engineer, a great deal depends on the man himself.

The difficulty in devising any training course for engineers and scientists who will ultimately occupy responsible positions in industry is to strike a balance in which the man is taught what it is desirable that he should know and yet that he should not spend too many years in academic study and so defer the date when he makes some contribution in industry and starts to earn a living for himself. In the case of engineers and scientists employed by the process industries for the development of new plants we must add the fact that they, more than most scientists and technologists, can be successful only if they have an intelligent appreciation of the work and difficulties of the men whose specialist skills be in other bands of the spectrum. It is men with the necessary theoretical and practical training and with this sympathetic breadth of outlook who are so much needed.

'The Process Engineer in the German Consumer Goods Industry,' by Prof. K. Riess (director, Farbenfabriken Bayer A.G., Germany).

In the consumer-goods industry, there are numerous tasks which presuppose special physical understanding, such as for example the treatment of ores, coal, stones and earth, foodstuffs, etc. Such tasks are, in Germany, allotted to the process engineer, who in comparison with the classical mechanical engineer has had a deeper training in their physical basis (unit operations). In processes in which, in addition to the physical changes, chemical reactions play a considerable role, as for example especially in the chemical industry, the process engineer works together with the chemist in Germany. Such teamwork has the advantage that the training of the process engineer as well as that of the chemist need not be less deep, so that both partners can bring to bear the full basic knowledge of their separate specialities. This broad basis enables the team to solve the most demanding tasks in development, planning and process operation.

'The Function of the Chemical Engineer as a Link Between Pure Research and its Industrial Application,' by Dr. L. Morandi (vice-president, Montecatini Co., Italy).

The chemical engineer is considered in his important task of maintaining interest in applied research as well as keeping up with the progress of the scientific world.

The chemical engineer effects the first control of an economic nature on the results of research. Imagination in the field of chemistry must be encouraged, therefore scientific research must be free of all ties and applied research must also enjoy a certain liberty. The chemical engineer intervenes, at and after the pilot installation stage, bearing in mind the economic aspects.

'Considerations of Technical Staff Requirements in the Evolution of an Industrial Chemical Project,' by Dr. R. Holroyd (Imperial Chemical Industries Ltd.).

The various stages in the evolution of an industrial chemical project from the conception of the original idea to the design of the full-scale plant are discussed. The closest collaboration between technical staff of varying training and experience is shown to be essential, not only at certain stages but throughout the course of the evolution process. The value of providing a substantial proportion of industrial technical staff with experience in more than one field, for example by giving a research chemist experience in plant operation, is emphasised, as is also the need for all staff to acquire an attitude of mind which enables them to identify themselves with the ultimate objective of economic production of some worthwhile product.

It is concluded that, in the chemical industry, there is great scope for the chemical engineer and that the fact that chemical engineering courses of instruction vary considerably in character might well be more of an advantage than a disadvantage. A chemical engineer, as is the case with a man trained in any other technical or scientific discipline, must recognise, however, that his academic training is only a beginning and that the type of work which he will most enjoy and in which he will be most effective will only become apparent after he has acquired some actual industrial experience.

'The Chemical Engineer in the Man-Made Fibre Industry,' by C. F. Kearton (Courtaulds Ltd.).

An account is given of the setting up and organisation of a chemical engineering section within a firm in the man-made fibre industry. The background to the action is sketched in, and an indication is given of what the particular company was looking for in the person of the chemical engineer. The position of the section within the research and development department is touched upon. The work of the section is illustrated by some examples, which are intended to bring out the relations between the section and different technical departments of the firm. Finally, mention is made of staff mobility and the training of new recruits.

### Discussion

**Dr. W. D. Scott,** opening the discussion, said the papers were remarkable for the uniformity of opinion of the authors on the main functions of chemical engineers and the way in which they were employed in our various organisations.

He spoke mainly from the business point of view rather than the technical. In the course of his remarks he said that a big difference between this country and the United States was that the young men in the States had a highly developed commercial sense, inculcated at school by the youth co-operative institutions which were sponsored by so many of the big business men there.

**Mr. C. F. Berglin** (Australian Atomic Energy Commission), speaking of the bridging of the gap between chemists and engineers, discussed ten fundamentals which had to be considered in a new chemical engineering project, of which seven were related to design and three were operating conditions.

To achieve the best compromise, he said, the chemical engineer must be an artist; in other words, he must be an engineer at heart. It was important to ensure that our few chemical engineers were not diverted into fields of activity which were better and more satisfactorily studied by specialists, such as research chemists and those concerned with applied chemistry, and maybe mechanical engineers. Three things were clear. First, more chemical engineers were required in industry; second, methods of education and training must be constantly under review to ensure that they were up to date; and, third, education authorities must ensure that the courses in chemical engineering were sufficiently widespread.

**Dr. R. J. Morley** (National Coal Board) discussed the value of pilot plants, about which Dr. Holroyd and Sir Christopher Hinton had passed some rather 'rude' remarks.

**Dr. R. Lessing** emphasised imagination as one of the most important features of the human mind in applying chemical engineering. The problem, he said, was how to direct a man's training so that such imagination as he had was not put out by cramming known facts into his brain, and to provide opportunities for him to develop imagination during his training; the latter was more likely to be possible during his actual work. From that point of view the device mentioned by Dr. Holroyd, and which was used in I.C.I. to a very large extent, of changing people from one job to another might allow their horizon to be widened and enable them to conceive the whole picture of what would be wanted in working out or conducting a project.

**Prof. D. M. Newitt** (Professor of Chemical Engineering, Imperial College, London) said Mr. Kearton's paper brought a real Elizabethan spirit. There were no doubts and misgivings as to what to do with chemical engineering; he had a team, including mechanical engineers, chemical engineers and chemists, and they set out to develop plant and processes without any doubts as to their capacity to do it. It was most heartening. Messrs. Courtauld's team of planners in this country had drawn up their designs and had carried out the pilot-plant work; then they went to America and built the plant, and it was now operating. Prof. Newitt quoted from the paper a sentence which, he said, all should memorise, and which related to that work: 'The large units of equipment, extensive mechanical handling, comprehensive instrumentation and automatic control, and certain design features, have given a factory whose rayon output per man hour is higher than any other of which we have knowledge.' That was what a team of competent chemists and mechanical and chemical engineers could do, supported by a board of directors. We in Europe could recover technological initiative; he always told his students that one of their missions, as soon as they went into industry, was to have before them the great task of recovering technological initiative.

Again, in talking of young chemical engineers who had just left the university, Mr. Kearton had stated: 'They all had in common a determination to be recognised as chemical engineers, and a fervent belief in the value of the chemical engineering approach and specialised technique.' Prof. Newitt hoped they would retain that fervour and their pride in being chemical engineers and very important members of any development team.

Finally, he felt that the chemical plant manufacturers had a great deal to learn from the chemical engineering approach, and he hoped they would read Mr. Kearton's paper again to see how a bold policy could be justified.

**Dr. A. Parker** (Director, Fuel Research Laboratory) agreed with Sir Christopher Hinton's idea of a spectrum, which he visualised as having at one end the pure chemist and at the other end the pure physicist, with the chemical engineer and other engineers in between. But we must remember that each member of the team differed somewhat from the others; they all had different absorption bands for knowledge and some of those absorption bands overlapped—that was the important point. Wrapped up in it there were mathematics, economics (including statistics and market research) and the power to assess what labour could and could not do. It was the right attitude of mind that we wanted in chemical engineers, and that meant that we wanted a variety of training.

He also stressed the point that at least a proportion of the teaching staff at the university should have had some experience in industry, for with that experience they could the better inculcate the right attitude of mind.

With regard to the argument that we had too much pilot plant and were not imaginative enough to go straight to the commercial plant, Dr. Parker said he could think of a number of processes where we could probably go straight to the full-scale plant; but there were many other cases where we should be courting disaster if we did that. One could perhaps call to mind cases where millions of pounds had gone down the drain as the result of trying to take a short cut. Again, sometimes it was necessary to put in a pilot plant to convince business executives that it was wise to spend money on a project. So that he did not think there was a hard and fast answer to the question concerning pilot plant.

**Sir Christopher Hinton,** replying to some of the points raised, referred first to visualising a team as a spectrum and said that, if we improperly composed a team so that part of its energy would be uselessly absorbed, we should waste energy. It was entirely a question of selecting the team—of selecting the spectrum to suit a particular problem.

On Mr. Berglin's point that a chemical engineer must be an engineer at heart, he said that chemistry, if we thought of it as a pure subject, was a science, and in science the answers to any questions were absolutely right or absolutely wrong. On the other hand, engineering fundamentally was not a science, but an art, even though it had a scientific basis. The characteristic of all the arts was that we were looking for a compromise between all sorts of conflicting advantages and disadvantages; and that was what we were doing in chemical engineering, or we were trying to optimise the solution of a problem. If that was what Mr. Berglin had in mind he would agree with his suggestion.

**Dr. Holroyd,** replying to Dr. Morley concerning pilot plant, said he had not intended to imply that all semi-technical work should be avoided. But he emphasised that when we undertook the empirical approach we were lacking a certain amount of fundamental knowledge. We should undertake research to rectify that situation, and certainly we should take every step to use all the knowledge we had

in order to cut out semi-technical experimentation altogether, or at least to cut down its scale. He felt that Dr. Parker was right in saying that projects should be considered individually.

Finally, he appealed to Prof. Newitt not to encourage his students to cling so very strongly to the chemical engineering banner. He had seen perfectly good chemists turned into perfectly good chemical engineers and, no doubt, in due course we should see good chemical engineers turned into good research chemists. The important point was that we were after good chaps; and in whatever field they had received their academic training, so long as that training had been good, industry could make good use of them.

**Mr. Kearton,** commenting on the references made to 'convincing the business man,' said the phrase was anathema to him. It implied that industry was controlled, guided and directed by men whom one envisaged as being concerned solely with quick returns, profitability and whose attitude was one of scepticism about anything their scientific people told them. He believed that in the United Kingdom that breed was dying out, and a very good thing too. Recent statistics indicated that technical people were getting on to the boards of companies, particularly the large companies, more and more. That was very much the rule in America. The conclusion one drew from experience was that there was no substitute for science at the highest level. The chemical engineer could not possibly have made a contribution without scientific discoveries and without ability of the highest order. Experience also showed that, in designing, building and operating good plants, there was no substitute for chemical engineers; they were in fact the catalytic agents in today's technology to the rapid advancement of industry, the use of natural resources and everything which went to make a fuller and better life.

**Sir Harold Hartley,** summing up, said it was fortunate that at the first session they had obtained the views of operators such as Sir Christopher Hinton, Dr. Holroyd and Mr. Kearton on the functions of the chemical engineer, so that the conference had a picture of the practical objectives of the education to be discussed in subsequent sessions; unless they started from that, the discussion of curricula would be of purely academic interest.

Dr. Riess and Sir Christopher Hinton had rightly emphasised that there were certain techniques running through the whole of the processing industries, and therefore the conference was discussing a much wider field than the chemical industry, although many of those techniques had their origin there.

Then Dr. Riess had spoken of the differences of the developments in his own country and in the United States and was rather critical of the term 'chemical engineer,' as he had found it difficult to combine the two points of view —to combine the experience of the chemist and the engineer in one person; he had thought that those who tried to do so were sacrificing thoroughness to versatility. His thought was for a process engineer, not a chemical engineer, with an emphasis on fundamental training and a sufficient knowledge of chemistry to enable him to co-operate with the chemist. So that, in terms of Sir Christopher's spectrum, Dr. Riess's chemical engineer would lie rather on the design side, and he doubted the usefulness of the idea of a dual personality.

Dr. Morandi seemed to have approached the subject from the very realistic point of view of the needs of industry in Italy and had sketched the characteristics that he wished the chemical engineer to have.

To support the views of those who believed in the conception of chemical engineering as a fourth primary technology there were the papers from the operating side, by Sir Christopher Hinton, Dr. Holroyd and Mr. Kearton, who had spoken of their experience of men who had been trained as chemical engineers. Sir Christopher, with his broad spectrum, had emphasised the importance of the opportunity it gave to determine the right niche for each individual, because we could be certain of that only when a man came into industry; so that it was by giving him that wider experience that he could find his right band in the spectrum, although, as Sir Christopher had rather emphasised, there was the middle band of the spectrum, which dealt with optimisation, and where some of the chemical engineers would certainly find themselves.

He had also dwelt on the overlapping of the different bands and the sympathy and understanding that that gave, and also with the part which the chemical engineer, with his wider training, could play in keeping the other bands working in some definite directions.

Dr. Holroyd had given another point of view when he had spoken of the different stages through which a project passed and the way in which the chemical engineer played his part in them, and had again emphasised his value, by reason of the outlook he had gained in his training and his sympathy with other specialists.

All would agree with Prof. Newitt that it was most heartening to hear the results of a courageous experiment by Messrs. Courtaulds in forming their team of chemical engineers and others, and to see the way in which they had reaped the benefit within a few years.

The conference could not have had a better start than that given by the very careful statements put forward that morning.

## SECOND SESSION

*Chairman: Prof. K. Riess (Germany)*

'The Chemical Engineer in Plant Operation and Management,' by J. A. Oriel, C.B.E., M.C. (Shell Petroleum Co. Ltd.).

The author pointed to the attractiveness of life as an operating chemical engineer. Attention was drawn to the need for a careful regard for maintenance and improvement of existing equipment, avoiding deflection of energy from this to the building of new equipment.

The materials and equipment once provided, ultimate responsibility rests with operating staff, this leading to development of some studies in management. The need for allowing staff to develop in its own way, and the responsibilities and discipline that this enforces on management itself, was also discussed.

'Chemical Engineering—The Turntable of Technical Development in Plant Operation,' by E. Bognar (Compagnie de Saint-Gobain, France).

Whether it is a case of setting up a works to operate according to a new procedure or, on a lesser scale, an extension or partial modification, the goal to be attained in a modern enterprise is always dependent on the outcome of collaboration between individuals.

The research worker and the economist are generally far removed from the actual workings. The manufacturing staffs, the technical department and the construction staffs know the same atmosphere, but, their task being well defined, they see things in a different perspective.

The chemical engineer listens to all of them and his study takes count of the wishes and interests of each of them which he endeavours to express in a language that is understood by all.

We have to study the organisation of chemical engineer-

ing; above all, its function of liaison with factory operation. The restricted connections between people whose training and background are very different, poses human problems. The chemical engineer must be a psychologist and at the same time a diplomat. These go to make up his professional competence in the same way as his technical knowledge.

'The Chemical Engineer in Works Management and in Administration,' by Prof. K. Winnaker (chairman, Farbwerke Hoechst A.G., Germany).

To judge from the experience of German industry, it is not worth while to train technicians who are half chemists and half engineers. The complex problems of the chemical industry make it necessary to have not only chemists with a thorough and extensive knowledge of all chemical subjects, but also engineers who have been specially trained in technical processes in addition to a good basic training.

Works management in a chemical undertaking lies mainly in the hands of the chemist, supported and helped by the works engineer. Successful management of the works will only be possible if the chemist and engineer collaborate closely in a spirit of mutual understanding. What they have to do is to recognise the interaction of natural scientific phenomena in the problems to be tackled and to classify them according to their significance. If this is done properly, one is bound to see what special duties fall to the chemist and to the engineer in the daily routine. So that the chemist and the engineer will be able to speak the same language, it is of vital importance that they both have a basic training in which physical chemistry occupies its proper place.

Similar considerations apply to the administration of an undertaking. It is part of the administration's duty to make a distinction between the important and the less important so as to distribute its forces in the proper proportions. Misjudgment or failure on the part of the engineer can be the ruin of a firm, no matter how excellent its chemists may be; similarly, if a basic chemical reaction is misjudged or mistaken, the best technological processes evolved by the engineer may collapse. The balance of forces can be all the better maintained if the value and significance of those doing different work is realised and if the problems are rightly judged. In this matter, the human factor is vitally important—quite apart from material considerations—to a greater extent, in fact, than in works management.

'The Role of the Chemical Engineer in the Operation and Management of Chemical Plants,' by N. G. Chorine (Société des Produits Chimiques Coignet, Belgium).

For several years the necessity of training technicians who would be the link between scientific research and industrial application has been apparent in Belgium. The training of capable chemical engineers seems to be the best answer to this problem. Their role finds a first field of application in the design offices and continues with the construction, operation and maintenance of chemical equipment.

The necessity of training qualified chemical engineers has become more urgent in Belgium since the last war, with the constant development of the chemical industry.

The author examined the solutions brought to this problem.

### Discussion

**Mr. G. Brearley** commented on the presence of trade union representatives at the conference and urged that any time spent on the education and training of plant operators must pay rich dividends in increased efficiency and safety in operations; when we considered the enormous improvement in working conditions in industry, including safety measures, over the last decade we could not but be impressed by the contribution which the chemical engineer had made to that desirable state of affairs.

In his view it was in plant operation and management that the chemical engineer could make the greatest contribution, not only in the production of products we all needed, but also the provision of data which would assist his colleagues in designing better and cheaper products and the equipment for their manufacture.

**Prof. K. Riess** said one of the functions of a chemical engineer was the maintenance of plant, which was not just a mechanical function depending on engineering ability, but it also depended on understanding the chemical processes. Again, engineers were needed for machine construction—men who had had chemical engineering or process engineering training.

Referring to the German system, in which the chemist and the engineer worked side by side, he commented on the suggestion that it might be dangerous and said that, whilst there were some people who would never work with others, practical experience in Germany over about 30 years had shown that in the majority of cases the danger did not exist. On the contrary, there was an advantage in having two competent people working, each trying to do a little better than the other. The essential point was that each one—and he was speaking of university-trained people—should be in a position to develop his own subject further.

**Mr. S. A. Gregory** referred back into history, to the doctrine that the field of chemistry was so enormous that it was practically impossible for a man to master chemistry and mechanics at the same time. That doctrine had stuck, so that it had been very difficult to build up the conception of the chemical engineer as a man who was doing a special job; there was always the idea that he was attempting to do two jobs.

In this country we had chemical engineers who specialised in different things, therefore the concept of the chemical engineer as part of a spectrum exists in this country. Our friends in Germany were still trying to get round their problem of not admitting the term 'chemical engineer,' and it was really a problem of overcoming a tradition. He believed many of us in this country welcomed the process engineer as defined as being one member of our team of chemical engineers.

**Prof. S. Kiesskalt** pointed out that in Germany they were doing their very best to train engineers who would have a great deal of understanding of chemistry; whilst they need not be expected to be able to write chemical formulae, they were expected to be able to understand the chemist, and both must be able to talk the same language; they must both understand chemical physics, or they would not achieve their joint end.

**Prof. G. Lamb** (North Western University, U.S.A.) referred to the method of training chemical engineers in the United States as being quite successful. There they were trained to understand chemistry, mathematics and engineering, but they tried to squeeze it all down to fundamentals, putting emphasis on the more difficult mathematical aspects. He considered that the American chemical engineer was versatile.

He felt that the answer to the problem before the conference, as to what was the best training for the chemical engineer, would vary from one country to another. The smaller countries could not have 200 students of chemical

engineering in every university, but they could work in collaboration through O.E.E.C.

After pointing to the interchange of jobs as a very valuable part of the training of chemical engineers, he expressed the hope that there would be more interchange of information in Europe. The chemical industry in the United States 30 years ago had been very secretive, whereas today one of the reasons for the strength of the industry was that information was passed on, whereby chemistry developed rapidly.

**Prof. M. B. Donald** (University College, London), referring to the apparent disagreement as to what a chemical engineer was, said he was not quite sure whether that disagreement was due to wording, a difference of understanding, or whether it was really fundamental. It was stated in the paper by Prof. Winnacker that 'The experience of German industry has shown that in any case it is better to divide the work to be done in factories between a chemist and an engineer. . . .' That gave rise to difficulties of interpretation, for engineers could be divided into four separate and distinct classes, for which British universities provided courses: they were civil, electrical, mechanical and chemical engineers. He did not think that collaboration between chemist and civil engineer would give satisfaction in any chemical factory, or that collaboration between chemist and electrical engineer would do much better, but maybe between chemist and mechanical engineer it would be more satisfactory; the correct answer was joint collaboration between the chemist and chemical engineer.

Commenting on a remark by Prof. Riess at the previous session concerning the disadvantages of all compromise solutions, he said it was in the minds of all Englishmen that the compromise solution was the best one possible; so that the view that a compromise solution must necessarily be bad was one which we as a race would find it difficult to accept.

**Prof. A. H. Nissan** (Leeds University) suggested 'in all humility' that in Germany they did have chemical engineers, but they differed from others in the method of producing them. He believed that in Germany, as in other countries, chemical engineering problems could only be solved economically and efficiently and quickly if chemical engineers solved them.

**Prof. F. Morten** (Birmingham University), urging that responsibility should come as early as possible in the graduate chemical engineer's introduction to industry, said he had found that one of the major considerations in the minds of graduates and students was to find the opportunity to carry responsibility fairly early. They wanted to try their wings, and later they might be happy to spend a little time in the drawing office, and so on. Those who had done things on the operation side seemed to mature much more than those on the design side.

**Mr. Oriel,** replying to some of the points raised, said that much discussion had centred around the interpretation of words. There had been some criticism of a reference to 'maintenance' as being part of a chemical engineer's work, particularly the work of the operating chemical engineer. There seemed to be a misconception of what the operating chemical engineer had to do. If he were to keep his plant operating for 24 hours each day he could hardly afford to work on the catch-as-catch-can principle; maintenance had to be a pre-arranged and organised business which could be worked out only by the man responsible for the operating of the plant.

Speakers had worked themselves into a froth concerning the terms 'process engineer' and 'chemical engineer,' but he agreed with those who had said that we were referring to the same man, whom we in this country preferred to call a 'chemical engineer.' They all agreed that it was personality that counted in giving inspired leadership in the operation and management of plant.

**Prof. Winnacker** said they had been discussing whether, generally speaking, an engineer could be given training of such a nature that in the running of a plant he could do without a chemist, or conversely, whether we could train a student of chemistry in such a way as to give him enough knowledge of engineering methods that he could run a chemical plant without the aid of a plant engineer. In Germany they did not believe either of those possibilities would work out. Engineers in the chemical industry there were given special training, referred to as process technology, but that did not mean that process engineers were taught so much chemistry that they could take over the work of the chemist in running a factory.

If both parties had a thorough training in the basic natural sciences and if they tried to reduce every problem to the basic phenomena of physics and chemistry they would understand each other.

**The chairman,** at the conclusion of the discussion, said he agreed with the view that a chemical engineer was a particular kind of mechanical engineer who had had a special training lasting for many years, either in the works or in the university, or both; he was a chemical engineer in the sense in which the word was used in England. The method adopted in Germany had been described to the conference, but it was not claimed that it must be the right method everywhere, and it had been interesting to hear the opinions of others. On some points there might have been misunderstanding, but it must be due to langauge difficulties. As the result of the conference they would understand each other better.

## THIRD SESSION

*Chairman: Dr. J. C. Vlugter (Netherlands)*

'To What Extent can the Traditional Training of the Chemist be brought into Accordance with the Demands of the Recent Developments in Chemical Industry?' by Prof. K. Schoenemann (Institut für Chemische Technologie der Technischen Hochschule, Darmstadt, Germany).

The tremendous advance of chemical industry in the last few years and its further development depend in a decisive measure on catalytic and continuous processes. Their optimum planning is determined at least as much by unit operations and apparatus construction as by chemical and technological considerations, especially those connected with reaction kinetics, which the chemist naturally comprehends in general more easily than the engineer. Thus, in addition to the training of engineers in unit operations the training of chemical technologists must be promoted.

A certain amount of technological knowledge which would be to some extent beneficial can be incorporated as a subsidiary subject in the generally established training of the chemist. More extensive and thorough training, which would be necessary only for a limited number of chemists, requires, however, a curriculum widely differing from that used for the training of chemists to date.

'The Planning of Courses,' by Prof. T. R. C. Fox (Shell Professor of Chemical Engineering, University of Cambridge).

The planning of courses in technology must be made,

both with an appreciation of their special merits as subjects of university study and also with an awareness of their special dangers. This paper discussed briefly some of the broad principles which should guide the planning of courses.

'Instruction and Research in the Training of Chemical Engineers in Germany,' by Prof. E. Kirschbaum (Director, Institut für Apparatebau und Verfahrenstechnik, Technische Hochschule, Germany).

In Germany the words 'chemical engineer' and 'process engineer' really mean the same thing. Industrialists and scientists in this country are fully agreed that the chemical engineer is not in some halfway position between an engineer and a chemist, but is quite definitely an engineer. Consequently, his basic training during the first two years at college is the same as that of a mechanical engineer. Students are taught the principles of chemistry during this period. In the later stages of the course the chemical engineer spends far less time on the theory of design of prime movers than does the mechanical engineer. The time thus made available is devoted to the design of process equipment, chemical technology, organic chemistry and physical chemistry—as this constitutes the best foundation for good relations with the chemist. Particular importance is attached to training in design.

Even when working for his diploma the student comes into close contact with research, as he is very frequently required to solve problems which fall beyond the sphere of unit operations. When the student has taken his diploma he may spend one or more years on a larger piece of research, which can be used as a thesis for his doctorate. The inaugural dissertation, which can generally be regarded as an indication of a student's fitness for an academic career, offers an opportunity for a still more profound, independent study—either in detail or in a general way—of present-day problems.

'Some Notes on Chemical Engineering Education at Delft,' by Prof. H. Kramers and Prof. P. M. Heertjes (Netherlands).

Chemical engineering education at the Technical University of Delft is concentrated in the Department of Chemical Technology. All students in this department follow the same courses during the first three years of their study. In the last two years of the study a differentiation is possible between chemical engineering and the three 'research' directions, namely: (1) inorganic and physical chemistry, (2) organic chemistry and (3) biochemistry. More than half of the students nowadays choose the chemical engineering direction, which has an output of 50 to 60 qualified engineers p.a.

About 5% of the students stay after their engineering degree in order to work for a doctor's degree, for which a piece of original research work has to be carried out. On the average, it takes about three years to obtain a doctor's degree.

'Chemistry in Chemical Engineering Education,' by Prof. K. G. K. Peters (Senior Professor, Technical University, Vienna, Austria).

The modern training of engineer-chemists comprises two parts, one in the direction of applied chemistry, the other towards chemical engineering.

Experience in many industries, completed and verified by observations at the Technical University of Vienna, show that the most important things in the training of chemical engineers are in their education to logical reasoning and conveying to them a deep understanding of the basic subjects of mathematics, physics and chemistry. One should also aim at relieving the existing curriculum of such matter as only burdens the students with innumerable details which at any time can be found in the respective handbooks.

Besides the teaching of the theoretical and technical methods of procedure, the subjects pursued in the higher terms should comprise chemical thermodynamics and kinetics and the important scientific, technical and economic connections of the manufacturing of chemical products and goods for consumption.

Such a course of study would have to lay the main stress on chemistry. Chemical engineering should be based upon profound chemical reasoning. This can be achieved neither by a reform of the existing study schemes for chemists nor by a reform of the hitherto existing course of studies for mechanical engineers, but only by a new line of education which conveys the indispensable equipment taken from all branches of science and engineering but relieved of all mere encyclopaedic knowledge.

'The Role of Numerical Calculations in the Teaching of Chemical Engineering,' by J. Givaudon (Union of Chemical Industries, France).

Chemical engineering is an applied science. The importance of numerical methods in the teaching of chemical engineering is demonstrated. These calculations, although they cannot take the place of practical solutions for arriving at concrete and correct results, are, nevertheless, excellent for penetrating the gist of theoretical formulae and fixing the conditions of application of them. Such a method is not without its difficulties. These arise from the diversity of systems and units of measurement, from the need to graduate the exercises and projects, from the interpretation of results obtained and from the difficulty of getting the engineer to accept the idea of numerical results.

One pitfall is to be avoided; it should not be thought that the calculations are, by themselves, sufficient to provide the solution to all problems. The calculations only prepare the ground for the solution of problems; their use reduces the number of experiments, but it will not, in all cases, enable experimentation to be dispensed with.

'The Organisation of Practical Chemical Engineering Work at the University of Louvain,' by Prof. L. Hellinckx (Belgium).

In the course of this paper, the author pointed out that chemical engineering training must combine both demonstration and speculation. The chemical engineer's practical work should not be modelled purely and simply, in form and in substance, on the experiments carried out in chemical laboratories—to turn the chemical engineer too firmly towards the laboratory with its special attitude of mind and techniques means to divert him from the proper nature of his functions.

'The Training of Chemical Engineers at Louvain University,' by Prof. E. Mertens de Wilmars (Belgium).

The curricula for chemical engineers still provide the same kind of training for engineers in all categories up to the third year. It is only in the fourth and fifth years that specialisation is introduced. At Louvain, therefore, chemical engineers still have the same general training as other kinds of engineers.

The syllabus for their special subjects now includes chemical engineering, practical work and mathematical exercises in chemical engineering, advanced courses in

organic chemistry and chemical analysis, physical chemistry and advanced courses in industrial chemistry.

### Discussion

**Prof. L. Hellinckx,** commenting on the point raised by Dr. Peters on pilot plant, said that in Belgium it was felt that 'scale models'—a better term than 'pilot plant'—were extremely useful.

In the training of the chemical engineer it was necessary to consider the services he was expected to give in industry. In a small country such as Belgium they were generally inclined to accept compromise solutions. They had adopted the term 'chemical engineer,' which applied to a man who had a field of work which was not covered by the graduate in chemical science or by non-specialist engineers. He must have a general training as an engineer and a well-founded knowledge of chemistry and must also have his training as a chemical engineer.

Was that asking too much from one individual? It was a lot to ask; but they chose for that course only people who were capable—the best elements they could find.

**Sir Harold Hartley** said it would be unfortunate if differences of point of view were regarded as a main issue of the conference. Prof. Schoenemann's paper was important because it built a bridge between the two different points of view; and he had stated that development might well be along wrong lines for years if the technological training of the chemists was to be neglected because it was necessary to encourage the training of process engineers.

**Mr. F. I. Hurley** said that possibly there had been some lack of decision due to the very wide range which the term 'chemical engineer' had been used to cover at the conference, and he felt that the whole range should be considered. It seemed clear that the types of persons who would be suitable in one part of the range might not necessarily be suitable in another; much depended on personality and temperament.

He went on to discuss the question as to whether the education of the people who were to work in the different ranges should be the same; whether, for example, the training for the development engineer should be the same as for the person at the other end of the range, *i.e.* the operations engineer.

There seemed a fair measure of agreement on the sort of fundamental training that should be given—not only the fundamental knowledge of the sciences, but the knowledge of how to tackle problems—and the feeling was that that training should be the same for people who were to work in certain parts of the range.

In the development stage there was very definitely room for people with differing backgrounds, and he would have thought that in the other parts of the range there was also room for people with practical experience.

Because the chemical engineer had a very wide range in which to work, one of his most important functions was to establish and maintain communication with those who were working in the different parts of the range, both orally and in writing. It had been Mr. Hurley's experience that a vast proportion of technologists from universities were extremely weak in that respect, and he asked the university people whether it was possible to improve the standard of writing and communication of their graduates.

**Mr. C. L. W. Berglin** (Australia), urging flexibility of outlook in regard to courses, said we had first to put down all the various subjects on which the students might have instruction. Then with the blue pencil we should strike out quite a few, and we were left with three categories: (1) those subjects with which it was necessary for the student to have only a short acquaintance; (2) those with which he should have a more extensive acquaintance, but time would not permit us to give more; and (3) those of which the student could not have too much.

He left it to the individual countries or universities to decide into which of those categories they should put the various subjects; we must accept a compromise, which would vary from country to country and from university to university, and even within one university from year to year. We must plan to get the most important 'end product,' *i.e.* the graduate, on to the market as early as possible.

**Prof. Newitt** said it was fairly evident from the papers and discussion that a teacher in chemical engineering must have some industrial background. It was not sufficient that he should have been in industry ten years ago because, as Prof. Fox had pointed out and as all would agree, the teacher's function was not to train the chemical engineer in what was being done in industry now, but in what would be done there five or ten years hence. Therefore it was essential that the teacher of chemical engineering should keep in close touch with industry, which would take results in all branches of science and use them as effectively as possible; he should know the trends of industry and adjust his course accordingly.

With regard to independent work and thinking, one tried to provide for that in the university, although frustrated to some extent by the administrative side, which had examinations which took the form of the solution of problems in a limited time. One tried to make the problems realistic, but they never were, and if the student learned the technique of answering them he would pass with first-class honours. But one imagined every teacher would agree that a student 'came to life' when one gave him research to do on an original problem. Therefore he stressed the importance of research, not for itself, but as part of the training in chemical engineering.

**Dr. A. Klinkenberg** (Netherlands) felt it would be extremely important to undertake a study of the system of units and symbols, in order to arrive at a closer and more practical concept between our terminologies.

**Prof. T. R. C. Fox,** replying to the point as to whether the educational scheme should be the same for all types of people, said the answer was clearly "No." As to whether a university should try to spread itself over a large area or concentrate on a rather narrower field, he felt that on the whole the university school had certain advantages if it worked as a team and tried to narrow its enthusiasm and make people feel they were going somewhere, rather than to try to cover a vast ground. On the other hand, if the course were run properly he did not think it mattered very much, because a man who later became a development man did not know, when at the university, that he would do that.

With regard to the applied stage, when people came back very much later and had clearer ideas than formerly of what they wanted to learn, he believed that staff college training would pay real dividends. There were very many highly organised special courses across the Atlantic, some of which he had had personal contact with and admired very much; he would like to see more courses of that type for men to attend later in their careers.

In his view, few people were very good at expressing themselves until they knew very clearly what they wanted to say; we could not expect a man to write intelligent essays before he had digested the subject on which he was to write. But he could do it after he had been to industry. Industry prided itself on enabling men to express them-

selves more clearly; the reason was that the man in industry was more mature than when he was at the university.

**Prof. Heertjes** said that in the new organisations, before examinations were held, students were enabled to gather into small groups and were encouraged to discuss matters freely; that did much in the development of their individual judgment and gave them the ability to express themselves clearly.

Lessons should be concerned with fundamental principles. In the laboratories the students did practical exercises and were in constant contact, which developed their characters.

Again, there was close collaboration with industry; current problems in industry were discussed.

**Dr. Peters** said he would welcome it very much if all the colleges could have pilot plant; he was of opinion that the theoretical teaching of technology could be aided by small-scale systems.

**Monsieur Givaudon** said that scientific laboratories in France were co-ordinated by a State department, the National Centre for Scientific Research. It had at its disposal a number of research workers who were sent to work in various laboratories. Also it made its scholars work for a certain percentage of their time on nationally interesting problems. He hoped that National Centre would be able to continue its work. The problem of nomenclature in organic chemistry was extremely difficult and should be studied in the national laboratories.

**The chairman,** in his summing up of the discussion, said it had shown that it was very difficult for a person or a country to indicate what model should be followed by others.

At the university the time of the chemical engineering students should be given to fundamentals—the fundamentals of chemistry, physics and engineering; they should have an understanding of reaction techniques, thermodynamics and similar matters.

He felt that here and there a little too much emphasis was laid on the importance of unit operations; it was only part of the business. If the students knew the fundamentals they could later work out and design equipment with the aid of that background.

Speakers had stressed the importance of educating students in such a way that they were able to think independently, and that with such a broad education they could become really good chemical engineers. Again, it was said that a student of chemical engineering must have the mentality of an engineer, *i.e.* he must have the ability to compromise—to take decisions—sometimes even with insufficient knowledge, and that the extent of his success in his career would depend very much on his personality and temperament. The chairman doubted that personality could be inculcated at a university.

Finally he agreed that experimental training whilst doing research under the guidance of professors was very important at a university. It was also important that they should have training in industry.

*The latter half of the conference, comprising the fourth fifth and sixth sessions, will be reported in a forthcoming issue*

# Chemical and Engineering Research

## SOME RECENT D.S.I.R. INVESTIGATIONS

A LARGE number of investigations, covering a wide range of interests in science and industry, are described in the 'Report for the Year 1953-54' of the Department of Scientific and Industrial Research (H.M.S.O., 9s.). Among these are the following:

**Steam condensation.** More accurate design data for heat-transfer equipment in general would probably save between 5 and 15% of the metal now used in their construction. Even greater savings (from 20 to 40%) would accrue in making steam condensers if the steam could be made to condense as drops rather than as film. Work on this problem has been undertaken at Queen Mary College, University of London. In the first place the unusually high rates of heat transfer with 'dropwise' condensation were demonstrated and the performance of condenser tubes and condenser plates under these conditions was compared. Substances which would 'promote' dropwise condensation were then prepared and tested, the requirement being for a promoter which gave prolonged dropwise condensation and caused no trouble in other parts of the system. One compound has been tested for over 3,500 hr. without the promoting surface breaking down. The final stage in the work is to make check tests in an actual power-station condenser and design and manufacture of equipment for this stage is in hand.

Another investigation on steam condensation is in hand at the College of Technology, Birmingham, where heat transfer from condensing steam containing air is being studied. The presence of quite small amounts of air reduces the heat transfer considerably. Although this is not important in plant which is run continuously, since steps are taken to remove the air, plant which is run intermittently is bound to have air in the steam for much of the time.

**Thermodynamic measurements.** The collection and correlation of viscosity and thermal conductivity data has shown that accurate values over wide ranges of density and temperature are still very scarce. This is particularly true of substances with simple molecules. Information about these would enable existing theory to be checked and help in its extension. Work is therefore being undertaken, again at Queen Mary College, on measuring the viscosity of liquefied gases; the first is argon.

To provide data about thermal conductivity, equipment is being designed to measure it for a number of substances which are important to industry. Measurements will be taken up to and beyond the critical pressure from room temperature upwards. Particular attention will be paid to the conditions under which appreciable convection occurs.

Work on the properties of mixtures of gases is also being undertaken. So many mixtures are of practical importance that direct measurement for each one is impossible. Theoretical generalisations have therefore been formulated and these are being tested with experimental data obtained in the University of Manchester, in the Imperial College of Science and Tech-

nology, University of London and at the National Physical Laboratory.

**Complete gasification.** Experimental work on the gasification of coal fines with steam by the fluidised-solids technique has been continued at the Fuel Research Station using a small pilot-scale plant and a number of laboratory-scale units. In this method a dense turbulent suspension of fuel particles is maintained by a rising current of steam in a heated reaction chamber. Conversion of peat and of a variety of coals to gas suitable for chemical syntheses has been carried out under these conditions at temperatures of 800 to 900°C., but there were considerable losses of fuel as fine dust entrained in the gas. If this process is to be developed to an industrial scale, methods of utilising this entrained dust would be necessary. Another method of gasifying fines is to inject them with air or steam into a chamber maintained at a temperature of about 1,500°C. The ash of the fuel fuses to liquid slag which flows down to the base of the chamber whence it can be run off. The particles of fuel adhere to the fused slag and are not carried off with the gas. Experimental work has been done during the past year with a cyclone chamber 2 ft. in diameter, into which the fuel and air are blown tangentially so that rapid reaction is induced by the intense swirling action of the gases; up to 500 lb./hr. of coal fines have been gasified in this way.

**Oils and chemicals from coal.** Where coal is gasified by reaction with steam or steam and oxygen at high temperatures the resulting mixture of carbon monoxide and hydrogen can be converted into liquid fuels, waxes and chemical products by passage over a suitable catalyst, as in the Fischer-Tropsch process, which is of considerable potential importance to the economy of this country. The work in progress at the station is directed towards reducing costs and introducing modifications to increase its suitability for industrial application.

The catalysts used consist of metallic cobalt or iron with various additions to modify their properties. Part of the work is devoted to the development of cheaper and more active catalysts, with the property of directing the reaction to yield the more economically desirable end products, and to exploring the range of temperature, pressure and gas composition that can usefully be employed with them.

Much heat is liberated during the synthesis reaction and the desired products are only obtained if the temperature is rigidly controlled. An important part of the work, therefore, is concerned with establishing the most suitable type of reaction system to employ in a full-scale plant. To try out various systems a pilot plant to treat 2,000 cu.ft./hr. of gas has been built and, during the past year, has been successfully operated with a reaction vessel containing a 'fluidised bed' of cheap iron catalyst (see CHEMICAL & PROCESS ENGINEERING, 1955, **36** (3), 92).

Other sections of the work in this field are concerned with the basic chemistry of the process, and include gas adsorption studies on catalyst surfaces, the use of the infra-red spectrometer for studying changes in product composition and the use of radioactive isotopes as tracers in studies of the reaction mechanism.

**Coal volatiles.** In a fundamental study of the release of volatiles, loss of weight/temperature characteristics have been determined for a number of coals of varying rank and particle size when heated at a constant rate up to 600°C. Particle size has been found to have a significant effect both on the rate of loss of volatiles and on the maximum loss of weight. Further studies have been made of the influence of hot surfaces, in the form of electrically heated wires, on the ignition of coal volatiles. The quantity of smoke can be reduced by catalytic combustion on surfaces with a platinum base, but not by other oxidation catalysts which have been tried.

**Producer gas.** Tests on a typical steelworks installation suggest that producer offtake temperatures of as low as 520°C. (which is possible with the B.C.U.R.A.-Kent system of automatic control) can be obtained, provided that the mains are insulated. A producer gas having a high calorific value was made consistently. Also the British Coal Utilisation Research Association was invited to collaborate with member-firms in the glass and steel industries in carrying out furnace performance trials and acceptance tests of two-stage producer plant.

**Pelleting slurries.** The process for pelleting coal slurries on a vibrating tray has attracted interest in connection with other materials, including cement, iron ore and various chemicals. The operation of the tray at carbonising temperature, to produce agglomerates of fine coal, is being studied to see if a coke of satisfactory physical properties can be obtained.

**Hydrogenation studies.** The main effort on this programme has been concerned with the catalytic refining of benzoles and naphthas. A joint programme of the Coal Tar Research Association with the National Benzole Association has involved a comparison between the hydro-refining of six representative crude benzoles under various conditions of temperature and pressure and their refining with concentrated sulphuric acid. If the aim of the refining process is to produce motor benzole, then the results show that the catalytic process offers only marginal advantage over sulphuric acid refining; if purer grades of benzole are desired, catalytic refining is the more economical process.

In the refining of solvent and heavy naphthas the main objectives are water-white colour, colour stability and pleasant smell rather than low sulphur content. A process has been worked out for the catalytic refining of naphthas to achieve these desired results, which, compared to normal refining by treatment with concentrated sulphuric acid, offers an increased yield of up to 30%. In order to compare the economics of this process with treatment of the total crude naphtha with sulphuric acid or the other alternative, which is prefractionation followed by acid refining of selected fractions, much time has been spent in determining the optimum conditions for refining samples submitted by members and producing sufficient refined products from these for evaluation.

It has been found that hot-pressed naphthalene can be hydrogenated to give a high yield of tetrahydronaphthalene at any desired conversion up to 75%. Details of a commercial plant to produce a ton a day of tetrahydronaphthalene or, alternatively, a smaller amount of tetrahydronaphthalene, together with some sulphur-free naphthalene, have been worked out for one member.

**Oxidation studies.** The pilot-scale fluidised oxidation plant for the production of phthalic anhydride from coal-tar oils was commissioned early in the year and, after overcoming some initial difficulties, has given very encouraging results. From a coke-oven naphthalene oil, weight yields of up to 80% of phthalic anhydride have been obtained. No evidence of catalyst disintegration or catalyst carry-over with the products has been noted; control of the plant has been excellent and condensation of the phthalic anhydride has proved much easier than anticipated. It has not yet been possible to carry out a catalyst life test, but so far there is no evidence of a fall-off in activity.

Concurrently with the pilot-plant investigation a statistical study on the effect of catalyst composition and operational variables on the vapour-phase oxidation of naphthalene to phthalic anhydride is in hand with a view to determining the optimum catalyst and the optimum conditions for its use. The results indicate that much higher space-time yields (*i.e.* weight of phthalic anhydride produced per unit volume of catalyst per unit time) are possible than those at present obtained in commercial practice.

**Corrosion and coking of tar stills.** The study of the factors influencing the corrosion of tar distilling equipment was concluded during this year and a full report is being prepared.

Briefly, it has been found that corrosion of mild steel is caused either by inorganic salts or by higher boiling phenolic compounds. Alkali injection controlled the effect of the former but increased corrosion by the latter. Mechanical dehydration reduced corrosion by inorganic salts, but had no effect on the phenols. The effect of high-boiling tar acids increased above 275°C. and steam or vacuum distillation minimised their attack. The relatively small quantities of phenolic components could be neutralised by adding iron oxide, but the amount required was impracticably great.

**Team of chemical engineers.** Although valuable background information on plant problems such as corrosion and coke formation can be obtained by research in the laboratory, such knowledge can only be satisfactorily applied to the problems arising at a particular works if the conditions prevailing at that works are taken into consideration. During the past year the Coal Tar Research Association, by virtue of a grant from Conditional Aid funds for studies designed to improve British industrial productivity, has been able to institute a valuable new service to the tar distilling industry. A mobile team of chemical engineers has been recruited who will be available to visit members' works to advise them on improving the efficiency of their operations and processes.

The activities of the investigational team have greatly increased the number of samples on which data are required and considerable attention has been devoted to extending the range of instruments available and to the adaptation of the present instruments for more rapid routine measurements. Particular mention may be made of the development of a new technique for the determination of the thermal conductivity of pitch at temperatures at which it is semi-fluid and also of a simplified method of determining flash vaporisation equilibria.

The effect of composition and molecular weight on the specific heats of tar oils and the correlation of specific heats of tar oils and tar oil vapours have been studied and expressions have been derived which may enable specific heats of tar oils in the liquid and vapour states to be calculated from their boiling ranges and tar acid contents.

**'Filiform' corrosion.** The cause of this phenomenon is being investigated and means of preventing its occurrence are being sought. In the course of the work, typical examples of this form of corrosion have been artificially produced by inoculating coated and uncoated steel panels with a variety of salts and subsequently exposing the panels to high-humidity atmospheres.

**Metals from low-grade sources.** The most promising low-grade sources of selenium found so far by the Inorganic Group of the Chemical Research Laboratory have been the wastes arising from the purification of the sulphur dioxide produced by the flash roasting of pyrites. Some of the samples examined have been exceptionally rich, containing up to 80% of the element; on the other hand, comparable materials from other installations, even where a similar pyrites has been used, have been as low as 4%. Altogether, these wastes could provide a useful additional source of the element. Processes for recovering the selenium from these materials have been examined; two have been studied in some detail, and a third possible method is at present being investigated.

Germanium is increasingly in demand and its importance to the radio industry alone has necessitated continued search for further sources of supply. In addition to several zinc blends a number of waste wood products have been examined for presence of the element.

The preparation of certain elements in a high degree of purity is another topic engaging attention and research is carried out on the purification of metals not already in the collection of pure metals maintained at the Laboratory. Attempts are at present being made to prepare pure rare-earth metals, and the separation of rare earths from one another is being studied as a first step to obtain adequate supplies of the starting materials in a satisfactory degree of purity.

**Sulphur.** Although sulphur is now more easily available, Britain's dependence on imported brimstone emphasises the need for examining indigenous sources of supply. A laboratory method employing anaerobic microbiological digestion for producing hydrogen sulphide from raw sewage sludge, and based on normal sewage works practice, has been developed; elemental sulphur is readily obtained by orthodox chemical processes from the gas mixture evolved. At present the hydrogen sulphide is produced at the expense of the economically valuable methane formed during normal anaerobic digestion of sewage sludge, but attempts are being made to enable the two processes to proceed simultaneously.

Fundamental studies on the sulphate-reducing bacteria have shown that cytochrome, a respiratory pigment unexpectedly isolated from these strictly anaerobic organisms, is an important link in the chain of reactions by which sulphate is converted to sulphide. Work has also been started on the mechanism of bacterial attack on the aromatic ring, a problem not of academic interest only, since the efficiency degradation of certain industrial aromatic effluents depends on microbiological action. The break down of phthalic acid by an organism isolated from filter beds in which effluents are treated has been investigated; pyruvic acid has been identified as an intermediate.

**Dust explosions.** Work has continued at the Safety in Mines Research Establishment on problems associated with dust explosions in factories.

There has been a steady accumulation in the data required for the design of explosion relief vents. In particular, a simple hinged-door relief was most effective and appeared to offer little more obstruction than that given by a free opening; the latter, of course, is not normally practicable in factory plant.

Basic studies have been made of the propagation of flame in dusts with a view to developing an improved test for measuring the explosion hazard presented by dust-laden atmospheres.

In **testing of welded pipes and pressure vessels** by the British Welding Research Association, a pressure vessel previously tested has been fitted with six new nozzles of different kinds to examine the effect of reinforcement.

An equal branch welded connection, reinforced with a collar, has been analysed when subjected to four different loading conditions. A similar connection with 'triform' reinforcement is under test.

Difficulty was experienced in obtaining a butt weld between the bend and the tangents which did not fail before the bend, but this difficulty has now been overcome, and both pulsating pressure and bending fatigue tests have been completed and S/N curves plotted. Ancillary equipment for tests under combined bending and internal pressure has been made.

**Industrial waste waters.** It was mentioned in the previous report that percolating filters treating sewage were not only able to become acclimatised to the presence of cyanide but were also able to destroy the cyanide. It has now been found that the presence of sewage is not necessary and that percolating filters are able to break down cyanides when these are supplied as solutions of potassium, zinc, or cadmium cyanides in concentrations up to 160 parts HCN per million. Destruction of cuprocyanide and nickelocyanide was less complete and very little of the cyanide in ferrocyanide was removed by this method. The experiments so far have all been made with small-scale filters, but as it appears that the process might be of value for treating certain types of dilute waste waters containing cyanide, for example washing waters from electroplating, it is proposed with the help of an industrial firm to extend the experiments to a larger scale.

It seems likely that this biological process might be able to adjust itself to considerable fluctuations in the concentration of cyanide. Thus it was found that an experimental filter that had been acclimatised to cyanides still retained its ability to destroy these compounds after addition of cyanide to the filter feed had been interrupted for periods of up to five weeks. The nature of the organisms responsible for the destruction of cyanide is being investigated.

During the past few years there have been many reports of pollution of water courses by effluents from silage and the Water Pollution Research Laboratory was asked by the Ministry of Agriculture and Fisheries to obtain information on the volume and composition of these liquids. Experiments on ensilage under controlled conditions are being made by the National Institute for Research in Dairying, and an arrangement was made for the collection and examination by the Laboratory of samples from experimental silos at the Institute. The liquid from concrete tower silos was found to be about 135 times as polluting as crude domestic sewage and the total effluent from 1 ton of silage was equivalent to 7,500 gal. of sewage; effluent from a pit silo was much weaker, but it was probably considerably diluted with surface water. The main flow of effluent is produced over a relatively short period and biological treatment would therefore be difficult and costly. Suggestions for avoiding pollution are that the crop to be ensiled might be allowed to wilt for a few hours after cutting, and that the silage might be protected from rain. The volume of effluent would then be very much reduced, possibly to nothing.

**Drying of leather.** There is ample scope for economies in fuel consumption in the drying of sole leather, since a survey has shown that about one ton of coal is used to dry one ton of leather, and it is estimated that this could be reduced by two-thirds. Because moist leather can be damaged by heat, it is dried at relatively low temperatures. When a controlled, closed drying unit is used, it has been found on an experimental plant that a heat pump can be used to control the drying capacity of the air with a significant saving in the heat required. A heat pump unit suitable for installation in a large experimental drier in a tannery has been designed and constructed, and will shortly be in operation. Under conditions normally used in sole leather drying (70 to 80°F. dry bulb with a 10°F. temperature difference), the unit is expected to remove 12 lb. water/kwh when electrically operated, at a cost estimated to be half that of a highly efficient steam-heated unit with controlled recirculation. The heat pump operates as a self-contained conditioning unit, and within its range of operation can be set to produce any prescribed drying conditions. This eliminates the need for the expensive control equipment essential for steam-heated drying plants.

**Effluent problems.** Leather production calls for the use of large quantities of lime and lime liquors containing sulphides, the disposal of which in urban areas presents many problems. The removal of sulphide by means of air, flue gases and chlorine has been studied by the British Leather Manufacturers' Research Association and the economics of the various methods are now under consideration. The flocculation of spent lime liquors by polyelectrolytes has proved very effective, the flocculated lime being in a condition in which it can be removed by pressure filtration. A cyclone separator has also been constructed to test the efficiency of this apparatus in lowering the water content of lime sludge.

## Recent Publications

**Clad steels.** A clad plate consists of a high-alloy metal homogeneously bonded to low alloy or mild steel, and any fabricating operation which would leave the backing material exposed to the corroding medium cannot be used. This naturally precludes the use of riveting and focuses attention on welding. The factor of prime importance in making any joint in clad steels is to preserve the continuity of the cladding surface and, with this point in mind, all joints should be so designed and located that the corroding medium cannot reach the backing material. This is just one of the many interesting points presented in a handsome, illustrated 52-page publication by Colvilles Ltd. featuring the *Colclad* range of clad steels. Thermal conductivity, physical tests, carbide precipitation, hot forming and gas cutting are a few of the subjects covered.

**Pneumatic platen press.** From Electronic Processes Corp. (U.S.A.) comes a new leaflet, Form P554, describing the new *Ectrotherm* model 453 pneumatic platen press, which is designed for use in plastics welding applications throughout industry. The press is illustrated in its various flexible mounting arrangements adjacent to standard high-frequency generators. Dimensioned outline drawings and specification tabulations cover physical and electrical characteristics of the press and also of the associated adjustable automatic timer.

**Soldering.** An eight-page illustrated pamphlet from Enthoven Solders Ltd. features solder products including flux-cored solder wire, cored and solid solder preforms, solid solders, solders for high-temperature service, etc.

**Fluctuating-pressure transducer.** A miniature flush-diaphragm strain-gauge transducer is featured in Form PT 654 from Electronic Engineering Associates Ltd., U.S.A. They recommend it for applications requiring small size and light weight. There is an arrangement where the sensing diaphragm can be located directly in the surface under pressure to eliminate phase and amplitude errors in fluctuating-pressure measurements. The leaflet illustrates and describes the transducer, provides dimensional and construction information in mechanical drawings and gives electrical circuitry. Operating parameters are tabulated for the standard pressure ranges of the ½-in. diam. transducers, including 2½, 5, 10, 25, 50, 100 and 200 p.s.i.

# Plant and Equipment

## *Flameproof switches*

K.D.G. Instruments Ltd. offer a new design of flameproof switch to meet the requirements of B.S.S. 229 and have been granted a Buxton Certificate for Groups 2 and 3. The switch has been designed for atmosphere encountered in the petroleum industry, paint manufacture, distilleries, etc.

The flameproof enclosure has the following overall dimensions: $12\frac{7}{8}$ in. long, $5\frac{3}{8}$ in. wide and $4\frac{1}{8}$ in. high, and is fixed by two $\frac{1}{4}$-in. bolt clearance holes in lugs on the bottom of the box. The cable entry gland is tapped $\frac{3}{4}$ in. e.t. to take standard conduit, or a *Pyrotenax* flameproof gland (size G). The standard pressure connections are $\frac{1}{4}$ in. or $\frac{3}{8}$ in. B.S.P., or $\frac{1}{4}$ in. A.P.I. Ranges extend from a minimum of 30 in. w.g. to a maximum of 8,000 p.s.i., and a vacuum switch is also available ranged 0 to 30 in. mercury.

The switch unit employs a diaphragm sensing unit for vacuum ranges and pressure ranges up to 100 p.s.i.; above this pressure a Bourdon tube is used. Both these pressure elements operate one snap-action, single-contact, change-over switch rated at 5 amp., 230 v. a.c.

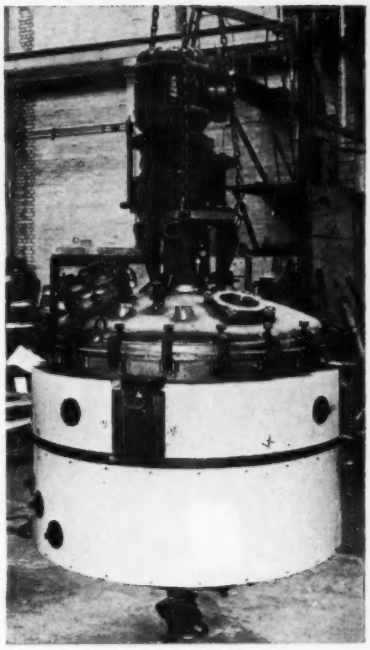
The following units are covered by the certificate:

(1) Diaphragm pressure switch, 0 to 30 in. Hg vacuum, 0 to 30 in. w.g. minimum, 0 to 100 p.s.i. maximum.
(2) Bourdon pressure switch.
(3) Double Bourdon pressure switch, 0 to 150 p.s.i. minimum, 0 to 8,000 p.s.i. maximum.
(4) Diaphragm pressure switch with calibrated setting dial and knob, 0 to 30 in. w.g. minimum, 0 to 100 p.s.i. maximum.

Items (1), (2) and (3) above are provided with a setting adjustment.

## *Electric surface heaters*

Problems involved in heating a stainless-steel vessel in a New Zealand chemical factory were overcome by using electric surface heaters in a novel way. The vessel, of 150-gal. capacity, had to be heated to a temperature of 275°C. and the same plant was also to be used for heating smaller quantities. It had to be made possible to heat the lower part of the vessel only and avoid overheating of the heat-sensitive material.

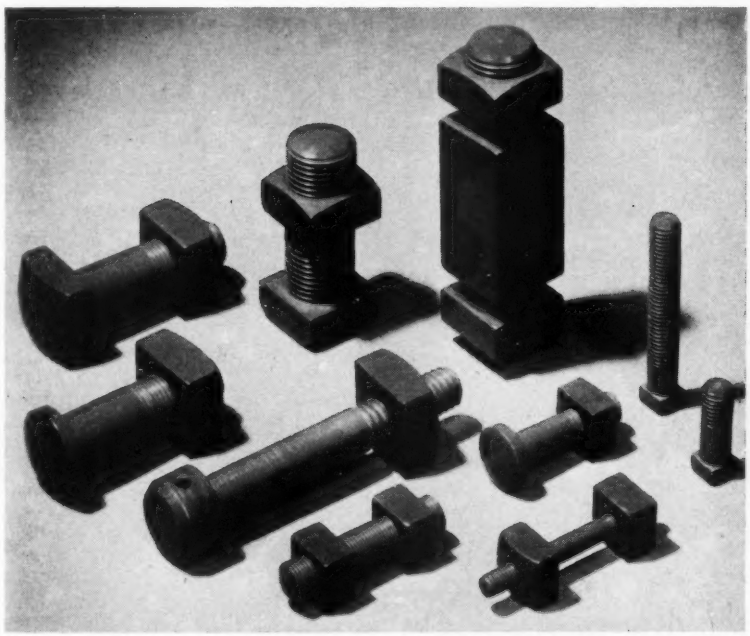


**Stainless-steel vessel heated by electric surface heaters as described on this page.**

These problems were solved by covering the vessel with an *Isomantle* surface heater which, in this particular instance, consists of a base heater section, having eight separate circuits, and four side heating units, each with an independent circuit. Each of these 12 circuits has a loading of 1,700 w., giving a total of just over 20 kw.

*Isomantles* comprise flexible heating panels made from glass fibre and resistance wire, which closely follow the contours of the vessel, and are backed by approximately 3 in. of glass wool for thermal insulation. The whole is covered and protected by stove-enamelled metal sheet. In the particular instance described, the appliance has to be used in a 'flameproof' area under which conditions standard resistance elements cannot be used. *Isomantles* for flameproof areas are using a special type of resistance element, consisting of the actual resistance core embedded in mineral insulation contained in a stainless-steel sheath. Each element leads into a flameproof terminal box.

The suppliers of these electric surface heaters, Isopad Ltd., point out that a particular advantage of electric surface heaters is the versatile and fine control that can be applied. The heating mantle for the 150-gal. vessel described has coarse control through



**A range of nuts and bolts is being manufactured by W. P. Coughlan Ltd., from 'Cobex' rigid vinyl, manufactured by BX Plastics Ltd. These nuts and bolts are stated to have a number of applications in chemical plant construction, enabling junctions to be made without the corrosion weakness inherent in metal nuts and bolts.**

flameproof three-heat switches and over-riding automatic control through a mercury-in-steel contact thermometer operating through intrinsically safe relays. The main control panel is situated outside the flameproof area, thus not only is it possible to disconnect the upper units when heating of the lower part of the vessel only is required, but any desired temperature up to 300°C. can be achieved, and the automatic controls can be set to maintain the chosen temperature without any further attention.

### Micro grinder

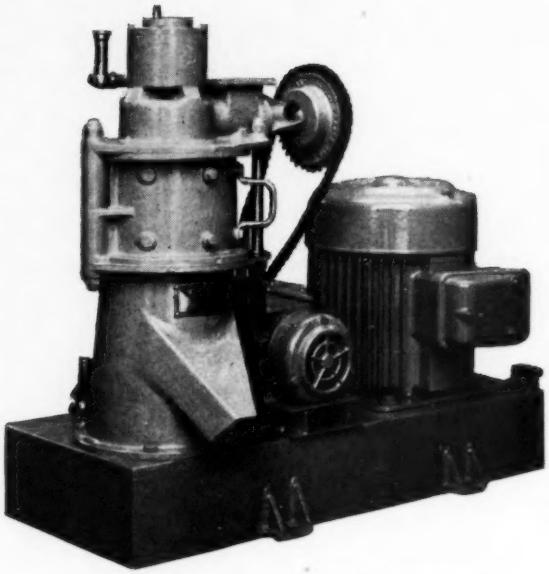
A micro grinder that is being marketed in the U.K. by the Moritz Chemical Engineering Co. Ltd. is a multi-stage hammer mill with vertical axis and is stated to be capable of reducing material of low or medium hardness to an extremely fine state of division. It is capable of grinding dyestuffs, limestone, lime, gypsum, talc, kaolin, cocoa, sugar, graphite, sulphates, oxides, pigments, filters, pharmaceutical products, resins, etc.

The machines are made in various sizes with capacities of ½ to 5 cwt./hr. (30 to 250 kg./hr.) and over. The ultimate degree of fineness which can be obtained varies from 1 to 25 microns (325 mesh sieves or finer).

The material to be ground is placed in a small hopper on top of the mill and a worm conveyor is used to maintain a constant feed at the proper rate to the first grinding stage and also functions as a seal. The material is pulverised between the hammers rotating at a high speed and the fixed grinding plates and wire screens. It passes through the first stage of grinding and is then automatically led to a central channel leading downwards to the second grinding stage where the same process is repeated. Mills with an additional number of grinding stages are available. The product is uniformly distributed at each stage of grinding by centrifugal force, and finally leaves the machine in the required state of division through a pipe to which sacks can be attached. The makers point out that, as the machine is closed at the inlet and outlet, it is completely dustless in operation.

The body of the machine is made of castings liberally reinforced with ribs and flanges. The central portion is provided with hinged doors for the inspection and rapid cleaning of the mill. The worm conveyor is driven by a motor through a variable-speed reduction gear and chain.

The main shaft of the mill is mounted on heavy-duty ball bearings and is driven by multiple vee belts. The motor is mounted vertically on the base plate.



**Mill for grinding a wide range of materials.**

Advantages claimed for the machine are that it requires a minimum of maintenance, occupies little floor space, is very simple in operation and is particularly suitable in cases where there are frequent changes in the materials to be ground and thorough cleaning of the grinding surfaces is essential.

### Bubble-cap columns in glass

An all-glass bubble-cap fractionating column has recently been brought out by Loughborough Glass Co. Ltd., and the makers feel that it will be a very useful tool for pilot-plant work and small batch production in the chemical industry. They point out that glass bubble-cap columns of a size suitable for pilot-plant work have been on the market in the past, but these have suffered from the disadvantage of having only one large cap per plate; they have not been very efficient, although their throughput was good. The new range of columns have a number of small caps on each plate, so providing high efficiency without sacrificing throughput, the makers claim.

This has been made technically possible by making the vapour-risers and downcomers detachable from the plates—an idea which has been patented.

The vapour-risers terminate in interchangeable cones which fit into tapered sockets in the plates, the latter being about ½-in. thick and made of heat-resisting glass. The bubble-caps and vapour-risers are sealed together to make integral units. These units could be retained in place by fitting pins, *e.g.* of *Teflon*, through the parts of the cones which protrude below the plate, but experience to date has shown that it would require considerable pressure to dislodge the caps when not pinned.

The columns are assembled by fitting the plates, with suitable gaskets, between standard pipeline sections. At present, columns are offered in 6-in., 9-in. and 12-in. diameters with two, five and nine caps per plate respectively.

All parts are standard and readily interchangeable. The columns can be built up to whatever number of sections are required without difficulty. By having access ports in the column sides, bubble caps can be taken out and cleaned or exchanged without dismantling the column. The holes in the plates can be stoppered if necessary.

### Geared motors and speed reducers

Two new types of foot-mounted and flange-mounted fractional-geared motors and speed reducers have been added to the standard range of larger industrial units made by Electropower Gears Ltd. Known as Types ESR 50 and ESRV 50, these new units have a maximum torque at 12 r.p.m. of 24.6 ft. lb. In certain cases slower speeds

are obtainable and the units are also available as a two-speed geared motor. The maximum standard ratio is 116.8 to 1; the minimum is 2.56 to 1.

Gear wheels, pinions and shaft are manufactured from high-tensile steel. The output shaft is fitted with ball bearings, while the first gear, second pinions and intermediate gear and final pinion revolve on fixed steel layshafts, the pinion being fitted with phosphor bronze bushes. Splash lubrication is provided.

The gearbox is self-contained, the motor being bolted on by four bolts after assembly. Motors of the three, phase, single-phase, d.c., variable-speed commutator, protected or totally enclosed types, complying with the usual British Standard Specification, can be fitted. Units suitable for Canadian and American specifications are made. A high-speed shaft can be brought out at the back end of the motor, if required. Oil seals are fitted to the final shaft and motor flange shaft. The units are available as self-contained speed reducers with input flange and shaft suitable for driving by flexible coupling or belt drive.

### *High-speed laboratory mill*

A new high-speed laboratory mill is being produced which, according to the makers, will grind and disperse materials in at least one-tenth of the time normally taken by an orthodox ball or pebble mill. It is stated that it will also mill to semi-paste consistency, grinding materials wet or dry and, if necessary, process four different substances simultaneously. Formulations processed in this new mill can be reproduced in bulk production with identical characteristics—the time factor is the only variable.

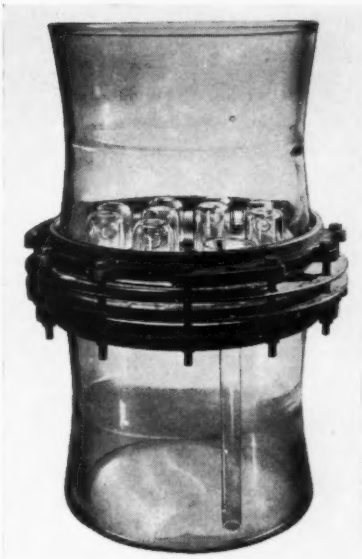
Whilst the mill has a wide range of applications in many branches of industry, the makers state that it is particularly suited to the paint industry and the paint manufacturers' laboratory.

It is claimed that materials which previously have proved almost impossible to disperse satisfactorily in orthodox ball mills can be processed rapidly.

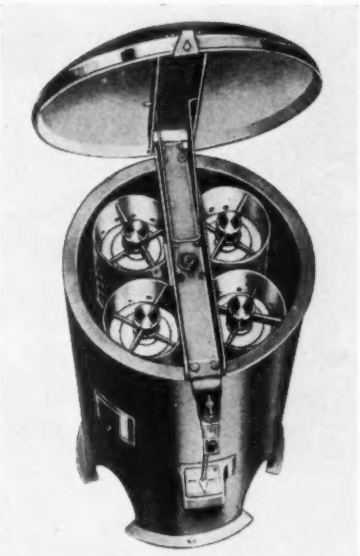
In addition, the design of the mill is such that the pots are removable and interchangeable and so positioned that a complete change-over of materials can be carried out in two or three minutes. Standing time is reduced to a minimum by the fact that it is unnecessary to clean the mill between runs, the only delay in production being the substitution of freshly charged spare pots.

This new mill, which is known as the Steel-Shaw high-speed laboratory mill (Mark I), is manufactured by Steele & Cowlishaw Ltd. The overall dimensions are 2 ft. diameter × 4 ft. 6 in. high, and the mill contains four hard-porcelain pots of 5 pints total volume giving a grinding capacity of 2½ pints of material per pot or a total milling capacity of 10 pints.

Also in production by the same company is a high-output 'smalls department' mill (Mark II) which employs the same principles of operation and takes four 5-gal. pots.



**Glass bubble-cap column.**



**High-speed laboratory grinding mill, showing interchangeable porcelain pots.**

## NEW PRODUCTS IN BRIEF

Two-way control valve for use in dust-control systems. Can be used for all types of dust, clippings, granular materials and wood waste. Device consists basically of a 'Y' piece containing a metal chute which can be pivoted to direct the flow of gas and material as required (Dallow Lambert & Co. Ltd.).

★

Self-aligning rotator for positioning tubular structures between 2 ft. and 12 ft. diam. to facilitate welding. No adjustment required when changing diameters. Can handle up to 20 tons in weight. (F. Bode & Son Ltd.)

★

Corrosion-resistant neoprene lining compound that flows on like paint to a variety of industrial surfaces—fan blades, fume ducts, process vessels, pump impellers, valves and piping. Makers claim excellent strength and adhesion. (Pennsylvania Salt Mfg. Co., U.S.A.)

★

New heating apparatus for laboratory use, claimed to combine advantages of gas burner with cleanliness and easy control. Can be used for heating test tubes (in about 10 sec.), crucibles, small flasks and beakers independent of their shape. Inverted, can provide heat source for evaporation processes. (Electrothermal Engineering Ltd.)

★

Polythene pail designed primarily for industrial and institutional purposes. Holds 2½ gal. and has heavy-quality steel handle completely encased in polythene. Full protection against acids and other corrosive fluids is claimed. Pail is calibrated on the inside in gallons and litres. Price 27s. 6d., in green, red and ivory. (Halex Division, British Xylonite Co. Ltd.)

★

Sonic gas analyser, making use of fact that the velocity of sound varies from one gas to another. Maximum sensitivity is claimed to be full scale for 1% by vol. of one component. In present model, all the electronics, including a stabilised power supply, are housed in single case, with sample tube attached by flexible cable. A phase-shifting network is incorporated which can be switched into the circuit at will. (Sir Howard Grubb, Parsons & Co.)

# Chemical Engineering Invention

## RECENT BRITISH PATENT CLAIMS

### Centrifugal separator

A steam-circulating device for use with a steam-heated heat exchanger comprises in a single unit a steam-water separator and a steam injector. The centre line *sp* of the path of the steam is of a simple U-shape. An elbow-like inlet *B*, the water separator *C*, a mixing nozzle *M* for the fresh steam injector *F*, and an elbow-like outlet *K* are all arranged so that their centre lines lie on that centre line, so as to minimise changes in direction of the steam flow and consequential friction.

In Fig. 1, steam from the heat exchanger *N* is partly separated from condensed water by an elbow pipe *A* with an opening *Y* for the separated water, and is further separated by rotation produced by a helical vane *D*. The fresh steam injector *F*, the outlet of which is adjustable by a valve *G*, entrains the separated steam and flows with it through an elbow *K* into the heat exchanger. The fresh steam pipe *P* passes through a flange *Q* by which the vane *D* is supported. Separated water collects in the sump *R* and is drawn off through a pipe *T*. A resilient strip *Z* with associated windows, or other velocity indicator, may be provided.

FIG. 2.

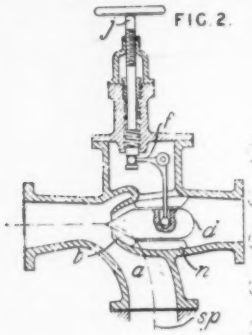



FIG. 1.

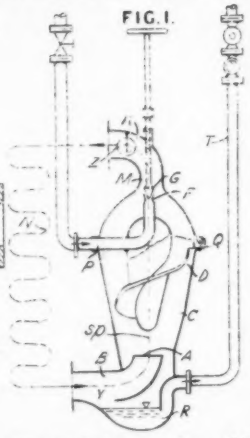



Fig. 2 shows a modification of the upper part of the unit, in which the steam jet nozzle *b* is directed horizontally towards the outlet of the elbow *a*. The nozzle *b* is controlled by a valve member *d* guided by ribs *n* and actuated by a screw-threaded spindle *j* and bell-crank lever *f*.—691,091, *G. F. Gerdts.*

### Control system for dust extraction plant

A control system is described for effecting timed and sequential operation of a number of similar units, such as a series of dust extraction units which require to be shut down, cleaned and returned to service in succession. It includes two electrically driven timing devices. One of these times is the operation and the other the interval between successive operations. The first device is brought into action on operation of a unit and the second comes into action on cessation of operation of that unit and initiates operation of the next unit.

The system may comprise a common control equipment, including the timers, and local control equipment for the individual units, the several local equipments being connected to the common equipment by a 'start' line and a 'stop' line over which electric impulses, controlled by the timers, are passed to the local control equipments.

Each local equipment includes a sequence relay which is actuated on completion of the operation of the associated unit, and prepares the local equipment of the next unit for response to the control impulse, whilst simultaneously rendering the former unit insensitive to further impulses.

When all the units have operated, a common tripping circuit for the several sequence relays is completed to initial another cycle of operations.

Each local equipment may include means for de-energising the associated unit and removing it from the sequence. The system may also include alarm apparatus responsive to faulty operation of the units, or power supply failure. Means may also be provided for temporarily cutting out the interval between successive operations.

As applied to a dust extraction plant, each local control equipment also comprises a torque motor which, under the control of an impulse from the central equipment, closes the exhaust valve, a limit switch associated with which brings about operation of a shaker motor for the filter bag and operation of the sequence relay for preparing the starting circuit of the next unit. A 'stop' pulse subsequently causes the torque motor to reopen the exhaust valve and stop the shaker motor. The next impulse from the central equipment passes to the following unit, which performs a similar series of operations.—693,352, *Power-Gas Corporation Ltd. and G. Wright.*

### Vaporising a liquefied gas

A liquefied gas of low boiling point, *e.g.* oxygen, is vaporised by passing it through an evaporator in indirect heat exchange with a stream of atmospheric air passing externally of the evaporator, the velocity of the air stream being so controlled that the temperature of the outer surface of the evaporator does not fall substantially below 0°C. Frost deposits on the outer surface of the evaporator are thus avoided.

The ratio of the surface area of the evaporator exposed to the air to that exposed to the evaporating liquefied gas is at least 10: 1 and the direction of flow of liquefied gas is periodically reversed.—696,576, *British Oxygen Co. Ltd., A. G. Monroe and A. W. Freud.*

### Carotene

Carotene is extracted from oils and derivatives thereof (*e.g.* fatty acids) by contacting them with finely divided activated carbon which has been freed of oxygen and eluting the carotene from the carbon. The oil is preferably de-aerated prior to treatment and may be warmed or diluted with a solvent (petroleum ether, acetone or ether) to reduce its viscosity.

The eluting solvent is preferably an aromatic hydrocarbon, *e.g.* benzene, toluene or xylene, and this may be used a number of times until a sufficient concentration of carotene is obtained. Pure carotene may be obtained from the concentrate.

The absorption and elution may take place on a column, in batches or continuously as in Specification 691,355. Examples show the extraction of carotene from Bissao palm oil and red palm oil. Carrot oil may also be used.—691,924, *Lever Bros. and Unilever Ltd.*

# World News

## GREAT BRITAIN

**New antibiotics plant**

A £2½-million fermentation plant built by Pfizer Ltd. at Sandwich, Kent, to manufacture terramycin and other antibiotic drugs has begun production. This is the first time the basic manufacture of terramycin has been undertaken in Britain.

**A.P.V. coppersmiths' shop**

The centralising of the A.P.V. Co. Ltd. at Crawley, Sussex, entered its second stage recently when the coppersmiths occupied what is believed to be the largest coppersmiths' shop in the U.K. This shop consists of three 700-ft. bays adjoining the existing engineering shops.

**Babcock & Wilcox subsidiaries**

Babcock & Wilcox Ltd. announce the fusion of the trading activities of two of their subsidiary companies, Spencer-Bonecourt Ltd. and the Clarkson Thimble Tube Boiler Co. Ltd. The name of the former company has been changed to Spencer-Bonecourt-Clarkson Ltd. and it will assume responsibility for all new business in Spencer-Bonecourt waste-heat boilers, the Clarkson marine and industrial waste-heat, oil- and gas-fired boilers and the new *Autoheat* oil-fired domestic boilers.

**Chemical companies' co-operation**

Bowmans Chemicals Ltd., of Widnes, announce that negotiations with Howards & Sons Ltd., of Ilford, which have been in progress for a considerable time, have now been concluded for a substantial measure of closer working between the two companies.

**Change of address**

To meet increasing demand the Birmingham office of Honeywell-Brown Ltd. has now moved from Stephenson Place to larger premises in Sutton New Road, Erdington, Birmingham 23.

**British Petroleum Co. developments**

**Oil gas for town use.** The South Eastern Gas Board and the British Petroleum Co. have agreed jointly to examine the practicability of building a plant to convert petroleum products available at the company's Kent oil refinery to town gas of acceptable quality.

The Gas Board have developed a catalytic oil gasification process capable of using a wide range of products from butane to heavy fuel oil and of producing town gas efficiently from all of this range of products.

It is expected that the initial installation would convert some 50,000 tons p.a. of petroleum products to gas. It would have a daily output of 15 million cu. ft. of gas and be arranged for extension to a capacity of 40 to 45 million cu. ft. daily with an annual petroleum usage of up to 150,000 tons.

**New chemical company.** British Petroleum Chemicals Ltd. and Oronite Chemical Co., of San Francisco, U.S.A., have jointly formed a new company named Grange Chemicals Ltd.

Grange Chemicals Ltd. will take over on completion the plant which British Petroleum Chemicals is building at Grangemouth for the production of *Alkylate*, a chemical intermediate used in the manufacture of high-quality synthetic detergents. This plant is due to be commissioned in the last quarter of 1955.

**Road shipments of gas.** A bulk road transportation service for liquid gas went into operation at Llandarcy refinery recently when a Shell-Mex and B.P. road tanker left the refinery with a shipment of butane for a chemical works in south Wales. Regular daily deliveries of liquid gas will now be made from the refinery for various industrial uses.

**Fifth platformer operating.** The British Petroleum Co.'s fifth platformer went into commission at Kent oil refinery, on the Isle of Grain, recently. It has a capacity of 250,000 tons p.a. and produces a high-grade motor spirit component by a reforming process which uses a platinum catalyst. The other four units are in operation in B.P. refineries at Aden, Kwinana (Western Australia), Lavera (France) and Hamburg. A sixth platformer is nearing completion at Llandarcy refinery, in South Wales, while the foundations for a seventh are being laid at Porto Marghera refinery, near Venice.

**Spirax-Sarco conference**

The 22nd annual engineers' conference of Spirax-Sarco Ltd. was held at the Palace Hotel, Torquay, from April 18 to 21. A prominent subject was the latest advances in the technique of automatic air venting of steam-heated plant. The practical aspects of 'individual steam drying' and selective steam trapping and air venting methods, and their influence in increasing the rate of production in a wide variety of steam-heated manufacturing processes, was related also to the needs at present arising in particular industries.

The simplification of thermostatic control problems, in both steam and hot-water installations and in cooling and refrigeration, was a principal subject on the agenda. Particular attention was given to the company's technical developments in the control of accelerated hot-water heating systems by automatic correction according to outdoor temperature variation.

**New orders for Power-Gas**

Since the war the Power-Gas Corporation Ltd. have completed or have under consideration 23 blast furnaces to produce in all more than 16,000 tons/day of iron, a figure that corresponds to almost half the total iron now being produced in the U.K.

This was stated by the chairman and managing director, Dr. N. E. Rambush, D.SC., M.I.CHEM.E., F.R.S.A., in his annual review of the company's affairs. He said the company could record with pride that the Indian Iron & Steel Co. had entrusted to it the construction of two blast furnaces for their Burnpur works. This order was secured against strong competition from other countries. Considerable orders have been received for chemical and gas plants, while various new products and processes adopted by the company are beginning to show promise. Oil gas plants, using the new South Eastern Gas Board process (Segas) have been ordered from the company, and the output of these plants will reach some 5 million cu.ft./day. The company are concerned, too, in the development of complete gasification plant, for which a unit is now being constructed.

Contracts completed during the year include two blast furnaces, four pig-casting machines, ten water-gas plants, one sulphur-removal plant, eight gasholders (spiral or frame guided) and ten Wiggins gasholders.

**Subsidiary companies.** Rose, Downs & Thompson Ltd. have completed and put into operation several new vegetable oil mills and refineries during the year. Deodorising plant, built under licence from the Girdler Corporation, of U.S.A., has been successfully put to work. Several solvent-extraction plants completed during the year are giving satisfactory service.

The Power-Gas Corporation (Australasia) Pty. Ltd. is at present fully employed on current contracts. The large and important contract secured from the Petroleum & Chemical Corporation (Australia) Ltd. for oil gas plant was taken against strong American competition.

### Overseas branch office

Humphreys & Glasgow Ltd. are establishing a branch office at 82 Elizabeth Street, Sydney, New South Wales. Two of their senior engineers from their London staff, Mr. Arthur S. Humphrys and Mr. Joseph R. Spangaro, will be in control in the new organisation.

### Change of address

Jenolite Ltd., the anti-corrosion specialists and manufacturers of industrial chemicals, are moving from their offices at Piazza Chambers, Covent Garden, W.C.2, to new premises at 13-17 Rathbone Street, London, W.1 (telephone: Museum 5411).

## WESTERN GERMANY

### Sugar-from-wood process

The Darmstadt Institute of Technology has reported success in experiments to make the extraction of sugar from wood an economic proposition. It claims to have produced 62 lb. of dextrose from 200 lb. of wood, compared with 40 lb. produced by earlier processes.

### Plastics production increased

West German plastics production last year was 325,000 tons (worth more than 1,000 million marks), 33% more than in 1953, a spokesman for the industry has disclosed.

This result brought West Germany to the second place among world plastics producers. The United States held the first position with 63% of the world output, followed by West Germany with a share of 11% and Britain with 9%.

### Fertiliser exports

West German exports of fertilisers last year amounted to about 423 million marks, against 370 million marks in 1953. Exports of nitrogenous fertilisers, which totalled 212 million marks last year compared with 182 million marks in 1953, represented the largest proportion. Next came exports of potash fertilisers, which were worth 181 million marks last year, against 164 million marks in 1953.

Fertiliser exports have not kept pace with the general increase in West Germany's chemical exports. Their share in total chemical exports fell from 16% in 1953 to 14% last year.

Production of nitrogenous fertilisers last year was about 696,000 tons (nitrogen content), compared with 625,000 tons in 1953. Production of phosphorous fertilisers ($P_2O_5$ content) rose from 426,400 tons in 1953 to almost 491,000 tons last year.

### The Leonard Hill Technical Group—May

*Articles appearing in some of our associate journals this month include:*

**Food Manufacture**—Mechanised Manufacture of Soft Drinks; Palatability of Chilled and Frozen Beef; Choice of Detergents for Food Factories; Pickle Making; Peanut Butter, 1; The Browning of Salt-Cured White Fish.

**Manufacturing Chemist**—Maleic Hydrazide; Quality Definition of Smell; Vitamins, 1; The Commoner Antihistamines, 2; The Phytosterols of Soya—Chemistry, Properties and Uses; Progress Reports: Pest Control Chemicals; Perfumery; Disinfectants.

**Paint Manufacture**—The Mechanism of the Drying of Oils—Some Recent Advances; Developments in Oils for the Paint Industry; The Production of Drying Oils; Thixotropy and Paints.

**Petroleum**—Instrumentation and Automatic Control in Oil Refineries, 5; Geophysical Methods of Oil Prospecting, 4; Petroleum Chemical Processes, 2.

**Fibres**—Survey of Developments in Instrumentation; *Fibres'* Review of Instruments; Fibre and Fabric Research; Fibre Data Sheet: Copolymerisate Fibres; Technical Progress in Man-Made and Synthetic Fibres, 1.

**Corrosion Technology**—The Protection of Metals by Paints; Corrosion in the Petroleum Industry, 1; The Protection of Structural Steel.

**Atomics**—Handling of Radioactive Materials, 2; Some Uses of Radioisotopes in Paper Making.

## PARAGUAY

### Industrial development

The Ministry of Industry and Commerce in Paraguay is studying the development of production and the establishment of new industries in the country, and foreign industrialists are invited to consider the possibility of setting up plants in a number of industries, including: dry distillation of wood—methylic alcohol, acetic acid, acetone, tar and coke; chemical fertilisers; wood pulp and paper.

A number of special facilities would be extended to new ventures. Firms who may be interested in these possibilities should address enquiries to the Board of Trade, London, quoting reference C.R.E./2711/55.

## HUNGARY

### Awards for scientists

Kossuth Prize awards to workers in Hungarian industry this year included an award of £1,000 to Dr. P. Dénes for an electrolytic method of producing iron and other alloy powders necessary for powder-iron patterns indispensable in the telecommunications industry. An award of £1,000 went to F. Ecker for making fire-resistant bricks and helping Hungarian metallurgical and other industries to make themselves independent of imports of fire-resistant materials; while £600 went to R. Konig for successful work in isolating and purifying medicinal materials of natural origin, ergot, alkaloids and penicillin.

## PAKISTAN

### Steel plant

Mining equipment and plant will be needed for a 600-million-rupees iron and steel factory to be built by the Pakistan Industrial Development Corporation. The factory will be built, largely, according to the designs and recommendations of Krupps, the German consultants of the Corporation.

The factory is to have an annual capacity of 100,000 tons of steel. Krupps have recommended that gas from the Sui project should be used for fuel, both directly and as a means of producing electricity. It is reported that the Corporation is going ahead with plans for piping gas to Kot Addu as well as for building a giant power house there.

It is hoped that the projected iron and steel factory will provide about one-third of Pakistan's iron and steel requirements.

The Corporation is making arrangements for financing the establishment of the plant. It is believed that private enterprises will be invited to participate, besides contacting the World Bank for a loan.

## INDIA

### New fertiliser factory

The Indian Government has accepted the interim recommendations made by the Fertiliser Production Committee for the establishment of a fertiliser factory in the Bhakra-Nangal multi-purpose project area in East Punjab.

The factory, which will produce ammonium nitrate, will have a capacity of 200,000 tons p.a. In terms of nitrogen content of the fertiliser, the capacity will be 70,000 tons p.a., which is approximately the same as that of the Sindri fertiliser factory in the Bihar State.

## ★ PERSONAL PARAGRAPHS ★

★ **Mr. B. T. C. Sawyer** is retiring from the post of chief engineer to Capper Pass & Son Ltd. and will be succeeded by **Mr. C. G. L. Francis.**

★ The chairman of the Babcock & Wilcox subsidiary company which is now called Spencer-Bonecourt-Clarkson Ltd. (see news item in this issue), is **Capt. (E.) W. Gregson,** R.N.R., formerly chairman of Spencer-Bonecourt Ltd. **Mr. S. W. Spurr,** managing director of the Clarkson Co., becomes managing director, while **Mr. A. E. Watkins** becomes deputy managing director of Spencer-Bonecourt-Clarkson Ltd.

★ **Mr. Robert R. Pierce,** sales manager of the Pennsylvania Salt Manufacturing Co.'s Corrosion Engineering Products Department, has been elected to the board of directors of the National Association of Corrosion Engineers, U.S.A.

★ **Mr. Francis L. Waring,** has been appointed managing director of Coalite & Chemical Products Ltd. and its subsidiaries. These subsidiary companies comprise Doncaster Coalite Ltd., the Derbyshire Coalite Co. Ltd. and the British Diesel Oil & Petrol Co. Ltd. **Sir Cyril F. Entwistle,** Q.C., M.C., who is already a director of the parent company, has joined the boards of the three subsidiaries.

★ **Mr. H. R. Burrows** has been appointed Birmingham and Midlands technical sales representative for Detel Products Ltd.

★ **Mr. W. V. Binstead** has joined the Development Department of the British Welding Research Association. In his capacity as a development engineer, he will be visiting industrial organisations where assistance is called for in connection with welding problems.

★ **Mr. E. R. Blane,** associate technologist at Vacuum Oil Co.'s central laboratories at Wandsworth, has retired after over 20 years' service. He is, however, remaining with the company for a limited period as a full-time consultant. When Mr. Blane came to the company, he already had wide experience as an industrial chemist. He spent 1913-14 in the United States in control of the manufacture of sulphonated oils for the leather trade for a Boston firm. After two years in England for war service, he worked for the British Dyestuff Corporation, Manchester, until 1921, when he became works manager for James Malcolm & Co. (Glasgow) Ltd., of Runcorn, Cheshire.

★ **Mr. Harold Rose** has been appointed deputy managing director of Expandite Ltd., specialists in joint sealing. He has acted as technical consultant to the company since 1948 and was appointed to the board of directors in 1953.

★ Following the acquisition of Petrochemicals Ltd. by Shell Chemicals Ltd., the directors appointed by the Finance Corporation for Industry Ltd., **Mr. Godfrey H. Owtram, Mr. E. J. Barnsley, Air Marshal Sir John Bradley,** K.C.B., and **Sir Robert Robinson,** O.M., have resigned from the board, as has also **Mr. P. C. Chaumeton.** Shell Chemicals Ltd. have appointed their own board of directors from within the Shell organisation.

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### ITALY

**Potash deposits in Sicily**

The presence of potash deposits in the Villapriolo district of Sicily has been definitely established, it is understood. The deposits are said to be of considerable commercial importance.

The Trinacria Co., which has been exploring in the area, has already drilled four holes. One of these is reported to have intersected a stratum of salt containing a workable thickness of about 30 m. of potash.

### ARGENTINA

**Synthetic phenol factory**

Synthetic phenol will be produced by a new enterprise called Febrica Argentina de Fenel Y Derivados S.A. A group headed by La Compania Quimica S.A., in which the firm of Bunge & Born has a substantial interest, has subscribed 65% of the new firm's capital. It is also learned that Farbenfabriken Bayer A.G., of Germany, will invest 375,000 U.S. dollars in the enterprise.

### FRANCE

**New blast furnace**

One of the biggest French steel concerns, Lorraine-Escaut, has started operation of a new blast furnace at its Longwy plant. The furnace is described as the most modern in Europe with an annual capacity of 180,000 to 200,000 tons.

This brings the number of blast furnaces in the Longwy plant to nine. Together with the eight open-hearth furnaces, they give an overall capacity of over 1,200,000 tons p.a. of pig iron.

### UNITED STATES

**New industrial fibre**

Before the end of 1955, Celanese Corporation of America will begin full-scale commercial production of their fibre X-36, which has been under development and evaluation for the last four years. Equipment and machinery are now on order for the operation, which will be located at the Rome, Georgia, fibre-manufacturing plant of the company.

Although a chemical 'brother' to *Fortisan*, the regenerated cellulose yarn which Celanese launched in 1940, the new fibre is made by an entirely different process developed specifically for the production of the heavy deniers required in industrial applications. It will be marketed as *Fortisan*-36 in continuous filament form. According to the makers, the new product tends to fill a gap which now exists between high-tenacity rayon on one side and glass fibre and industrial steel wire on the other.

**Fluorspar project**

The Pennsylvania Salt Manufacturing Co. has announced the incorporation of a new, wholly owned subsidiary for the development of extensive fluorspar resources in western Kentucky. Chartered as the Calvert City Chemical Co., this organisation will develop a new mine and expand existing milling and flotation facilities to meet growing requirements for acid grade spar used in the production of hydrofluoric acid and other fluorine chemicals at its Calvert City works.

Construction already begun under the direction of the company's central engineering staff is scheduled for completion later this year. Operations of the new mining-milling unit will be integrated with the activities of the Calvert City works.

**Steel company expansion**

The Armco Steel Corporation has issued details of a proposed $60-million expansion programme which will increase its steel-producing capacity by 400,000 tons to a total of 5,300,000 tons p.a., mostly in special-purpose grades of sheet steel.

Approximately $25 million will be spent at the Butler, Pennsylvania, plant for a 56-in. hot-strip mill, a new annealing and pickling line, widening of the present slabbing mill and relocation of Armco's railroad wheel works. At Middleton, Ohio, the company plans to spend about $18 million to add two 275-ton/day open-hearth furnaces and provide building space for construction of two additional

furnaces later. A $15-million expenditure at the Ashland, Kentucky, works will include addition of a second reversing cold mill, a strip normalising and pickling line, a complete sintering plant, a shipping terminal and extensive building additions.

**Organic isocyanates project**

The U.S. Allied Chemical & Dye Corporation's National Aniline Division has announced plans for a plant to produce organic isocyanates at Moundsville, West Virginia. The new plant will be a completely integrated facility, with all chemical raw materials supplied from within the Allied Chemical Organisation.

It has been planned for production of a varied line of isocyanates. Organic isocyanates, and the polyurethane products made from them, have been attracting considerable attention. They have recently emerged as a broad new class of synthetic organic chemicals with important large-volume potential as raw materials for the manufacture of improved synthetic rubbers, resins, plastics, adhesives, surface coatings and fibres.

### NETHERLANDS

**Oil refinery extension**

The Caltex Petrol Co. have announced that the refinery at Pernis is to be considerably extended at a cost of some tens of million guilders, with the addition of a ' platformer ' and a diesel desulphurising unit.

**Nitrogen project**

The firm of Mekog (an affiliate of Bataafsche Petroleum & Hoogevens) have announced that they intend to build a plant near Velsen to produce nitrogen from crude oil; it is planned to raise fertiliser output from 370,000 tons to 500,000 tons during the next few years.

### HONG KONG

**Cold-storage plant**

Slow delivery of the equivalent United Kingdom compressors was said to be the reason for employment of American (Frick) compressors in a cold store which was recently opened in a new seven-storey building of the Premier Development Co. Ltd. However, various driving motors for the plant were supplied from the U.K.

Special features of the cold store include a quick-freezing room, a fur room with individual lockers and the latest type of flake ice-making machine such as that which is being used successfully by fishing fleets of other countries.

### FINLAND

**Timber processing extensions planned**

Finland will use the recent $12-million loan from the World Bank for extending and modernising her timber processing industry and for building new hydroelectric power stations. About $8 million of the loan have been assigned to five timber processing companies for extensions of their factories and about $4 million for two power stations. The loan will cover one-fifth of the total cost of the projects. The rest will be financed by domestic capital.

About three-quarters of the loan will be used for material and equipment purchases for the projects from Denmark, France, West Germany, Sweden, Switzerland and Britain, and about one-quarter of it for purchases from the United States.

The five timber processing companies to receive aid are: Enzo-Gutzeit and W. Roseniew companies, who will increase production of sulphate paper pulp and kraft paper; Kymmene Co., A. Ahlstroem Co. and the Metsaeliiton Selluloosas Factory, who will modernise their plants and install new equipment which will economise on imported fuel and make it possible to process valuable waste products unused hitherto.


**CHEMICAL & PROCESS ENGINEERING**

*ENQUIRY BUREAU*

**Stratford House, 9 Eden Street, London, N.W.1**

Readers requiring names of suppliers of raw materials, machinery or finished products should complete this form and attach it to their business note-heading. Please state approximate quantities required.

**We wish to know names and addresses of suppliers of the following:**

_____

_____

_____

_____

For office use only. No. Date


## Hydraulic Transportation of Coal

(*Concluded from page* 170)

When it comes to future possibilities, various ways of turning the hydraulic transport of coal to other advantage, in addition to its main one of handling, can be seen.

Why pump the refuse up the shaft at all? Present-day methods and economics of winning, working and cleaning coal prevent the clean coal being loaded alone. In the past, when all coal was ' hand got,' very little dirt came up the shaft and miners were paid a bonus to use a ' riddle ' and load only the cleanest coal. More recently and at the present time coal is excavated and loaded by machines, and discrimination is impossible, making it necessary for large and expensive coal preparation plant to separate out the dirt, which, being heavier, costs more to move.

Another possibility would be to make the shaft a classifying column in itself, either by hydraulic methods, or by having an isolated column containing a stable medium, say crushed shale, at the density at which it is desired to separate the coal from the dirt. The run-of-mine coal would be fed at a point near the bottom of the column, the coal floating up the shaft and the refuse sinking to the bottom to be removed by means of extraction chambers.

When one considers pipelines such as the oil pipeline linking up the oilfields of Maracaibo with refineries at Cardon which are 150 miles in length, the feasibility of pumping coal from the main coal fields to heavy industrialised areas, maybe 100 to 200 miles away, does not seem such a remote possibility as may have been thought a few years ago.

In the future atomic era which has now dawned we can expect coal to be regarded more as a crude commercial form of carbon, or raw material for carbonisation, rather than a fuel in its own right. The extraction and handling of it by hydraulics can well belong to the near future when, as already mentioned, coal will have to be of small size. The last days of coal mines, which are already on the horizon, could be brought about by water transport or, in the case of thin seams, by underground gasification.